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Needs Survey (1978): Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharges

CH2M Hill Southeast, Inc, Gainesville, FL

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Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharge

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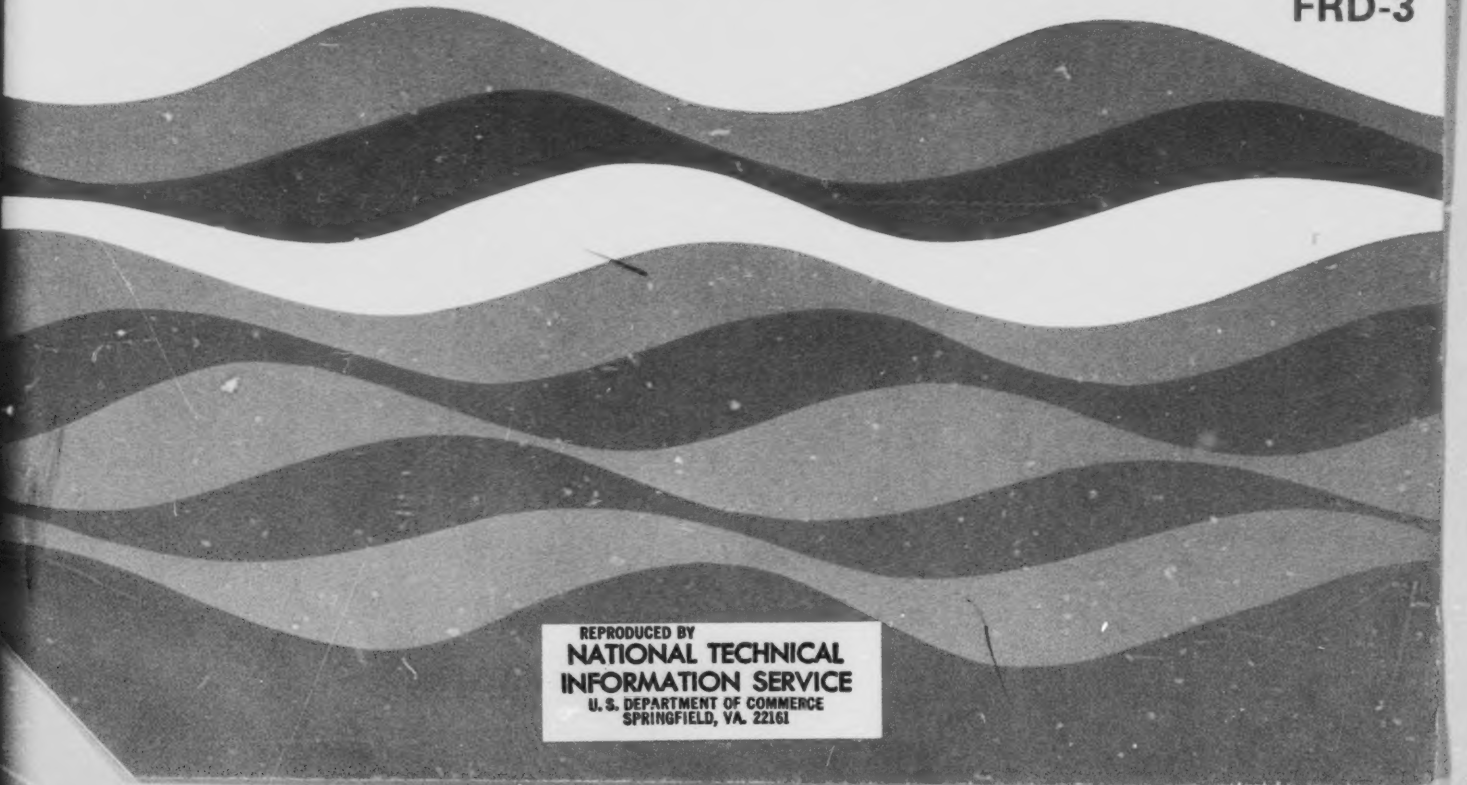

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16. ABSTRACT

The 1978 Needs Survey for Combined Sewer Overflow (Category V) and Urban Stormwater Discharges (Category VI) develops current and year 2000 capital and annual operation and maintenance cost estimates for pollution control facilities required to obtain three levels of receiving water beneficial use including the aesthetics level, the fish and wildlife level, and the recreation level. Estimated capital costs for year 2000 recreation level receiving water use are the needs reported to Congress. Cost estimates are based on consideration of the assimilative capacity of the receiving water evaluated by continuous hydrologic/water quality simulation and on the economic optimization of available control alternatives. These considerations are the major improvements of the 1978 needs estimate over the 1976 approach. This project has also resulted in the establishment of a national combined sewer system data file which contains information pertaining to 1,143 known combined sewer systems nationwide. Costs for control of combined sewer overflow reflect control needs. Needs for flood control and urban drainage are not included. Costs for urban stormwater discharges also apply to pollution control; however, these needs are not presently grant-eligible.

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1978 NEEDS SURVEY
COST METHODOLOGY FOR CONTROL OF COMBINED SEWER OVERFLOW AND STORMWATER DISCHARGES

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EXECUTIVE SUMMARY
1978 NEEDS SURVEY--COST METHODOLOGY FOR CONTROL OF COMBINED SEWER OVERFLOW AND STORMWATER DISCHARGES

National needs for control of pollution from combined sewer overflow (Category V) and urban stormwater runoff (Category VI) have been estimated for three receiving water quality objectives, the aesthetics objective, the fish and wildlife objective, and the recreation objective. The recreation objective is the only one of the three considered which will fully meet the requirements and goals of the Federal Water Pollution Control Amendments of 1972 (PL 92-500). Therefore, the recreation objective construction cost estimates are the needs reported to Congress.

Nationwide construction cost estimates for the aesthetics objective and the fish and wildlife objective are developed and reported herein in order to establish a relationship between the cost of pollution control for Categories V and VI and benefits measured in terms of beneficial receiving water use.

Costs for Category V reflect estimated grant-eligible pollution control needs. That is, needs for flood control or urban drainage are not included. Category VI estimates are also for pollution control only; however, Category VI needs are not presently grant-eligible. National needs for each catetory and receiving water objective are summarized and compared in Table ES-1 to those reported in the 1976 Needs Survey.

Combined sewers serve approximately 2,527,000 acres and 39,781,000 persons. Therefore, mean estimated Category V needs for the recreation level are approximately $10,188 per acre or $643 per person served.

In the year 2000, approximately 130,427,000 persons will occupy 32,244,000 acres in Urbanized Areas served by separate storm sewers. Therefore, mean estimated Category VI needs for the recreation level are approximately $1,913 per acre or $473 per person served. Mean unit capital, O&M, and equivalent annual costs for Categories V and VI are summarized in Table ES-2.

The 1978 estimated cost to achieve the aesthetics objective is lower than the 1976 estimated cost for both Categories V and VI. The difference in the case of combined sewer overflow control is explained by alternative technology. In the 1976 Needs Survey, aesthetics objective needs were based on providing swirl concentrators at all overflow points and consolidated screening of the concentrate. In the 1978 Needs Survey, aesthetics objective needs are based on providing an optimum mix of streetsweeping and combined sewer flushing. Both methods can remove approximately

Table ES-1
Summary of Categories V and VI National Needs Estimates (Billion January 1978 Dollars)

A. Year 2000 Needs for Combined Sewer Overflow Control

	Aesthetics Objective	Fish and Wildlife Objective	Recreation Objective
1976	6.5	14.0	21.2
1978	2.0	10.9	25.7

B. Year 1990 and 2000 Needs for Urban Stormwater Runoff Control

	Aesthetics Objective	Fish and Wildlife Objective	Recreation Objective
1976 (1990)	23.7	58.7	62.8
1978 (2000)	1.4	29.2	61.7

Table ES-2
Summary of Categories V and VI Capital and O&M Unit Costs for Year 2000 Recreation Level Conditions (January 1978 Dollars)

	Unit Costs	
	$ per person	$ per acre
Category V Capital cost	647	10,188
Category V O&M cost	18.38	289
Category V Equivalent annual cost	77.68	1,223
Category VI Capital cost	473	1,913
Category VI O&M cost	22.84	92.37
Category VI Equivalent annual cost	66.20	268

Note: Capital costs are total estimated grant-eligible costs, including planning design and construction. O&M costs and equivalent annual cost are both expressed as dollars per year.

40% of the combined sewer solids which are now discharged to the receiving water. However, the streetsweeping/sewer flushing combination has an obvious cost advantage. Although sewer flushing is a promising low-cost technology for control of pollution from combined sewer overflow, it has not been tested on a full-scale areawide basis. Further testing is necessary to confirm the cost effectiveness indicated in small-scale demonstration studies completed to date.

The difference in year 2000 aesthetics level costs in the case of urban stormwater runoff control is explained by differing assumptions related to the cost of storage of stormwater in newly developing areas. In the 1976 Needs Survey, the cost of storing stormwater runoff was assumed to be $0.50 per gallon, which is a typical unit cost for concrete storage basins. In the 1978 Needs Survey, it was assumed that stormwater storage could be designed into new developments in such a manner that earthen detention basins would be utilized. A typical unit cost for this type of facility is approximately $0.03 per gallon.

The 1978 estimated cost to achieve the fish and wildlife objective is also lower than the 1976 estimated cost for both Categories V and VI. The major reason for the estimated decrease in fish and wildlife objective needs is the economic optimization analysis considered in the needs computations. This optimization results in the selection of the most cost-effective mix of technologies at a given site for a specified level of pollutant removal. The economic optimization of pollution control alternatives is a major enhancement of the 1978 needs estimate over the 1976 approach.

The 1978 estimated cost to achieve the recreation receiving water quality objective is somewhat higher for combined sewer overflow control and slightly lower for urban stormwater runoff control. The approximately 21% increase in estimated construction cost for Category V needs is due to two factors. First, identified combined sewer service area has increased from approximately 2-1/4 million acres in the 1976 Needs Survey to approximately 2-1/2 million acres in the 1978 Needs Survey. Second, a more accurate estimate of storage volume required to achieve the recreation receiving water quality goal was utilized in the 1978 needs computations. This technique yields slightly larger values for required storage volume.

PROJECT OBJECTIVES

The major objective of this project is to develop updated nationwide cost estimates for control of pollution from combined sewer overflow (Category V) and urban stormwater runoff (Category VI) on a State-by-State basis.

A secondary objective is to establish the National Combined Sewer System Data File. This file contains information on every known combined sewer system in the nation, including location, sewer system and receiving water characteristics, and the status of current Combined Sewer Overflow (CSO) planning.

Receiving water quality objectives are developed in order to evaluate the need for control of pollution from combined sewer overflow and stormwater runoff based on beneficial use of the receiving water. The objectives are defined for three levels of water quality: aesthetics level, fish and wildlife level, and recreation level.

The indicator pollutants selected for the aesthetics objective are floatable and settleable solids, and the objective is based on criteria proposed by EPA in "Quality Criteria for Water."

The indicator pollutants selected for the fish and wildlife objective are suspended solids, carbonaceous BOD (CBOD), nitrogenous BOD (NBOD), dissolved lead, and total phosphorus (for lakes). The objective is to provide a receiving water suitable for the propagation of fish and wildlife. For this purpose, the allowable suspended solids concentration from combined sewer overflow and urban stormwater runoff was chosen to not exceed the mean value of background suspended solids for the receiving water on an annual basis, with a minimum limit of 25 mg/l.

The selected criteria for removal of oxygen-demanding pollutants (CBOD and NBOD) are based on dissolved oxygen toxicity limits for juvenile brook trout and on "Quality Criteria for Water," as follows.

> The minimum receiving water dissolved oxygen concentration shall not average less than 2.0 mg/l for more than 4 consecutive hours; nor shall the minimum receiving water dissolved oxygen concentration average less than 3.0 mg/l for more than 72 consecutive hours (3 days). In addition, the annual average receiving water dissolved oxygen concentration shall be greater than 5.0 mg/l for all waters which will support warm water species and shall be greater than 6.0 mg/l for all waters which will support cold water (salmoid) species.

In cases where the DO criteria cannot be met even if all pollutants from combined sewer overflow and stormwater runoff are removed, the removal requirements are based on elimination of 90% of the occurrences of low DO (<2.0 mg/l) which can be controlled.

The criteria for dissolved lead removal, based on extremely limited dissolved lead toxicity data for rainbow trout were developed as follows.

1. The mean instream 96-hour (time averaged) dissolved lead concentration should not exceed 0.33 mg/l.

2. The long-term mean instream dissolved lead concentration should not exceed 0.01 mg/l in soft waters (hardness <100 mg/l) or 0.025 mg/l in hard waters (hardness >100 mg/l).

Removal of phosphorus to meet the fish and wildlife objective is applied to all sources discharging into the receiving water with average annual lake phosphorus concentrations not exceeding 0.025 mg/l.

The objective of the recreation level is to obtain the fish and wildlife level and, in addition, meet the fecal coliform bacteria criteria recommended in "Quality Criteria for Water," which are as follows.

> Based on a minimum of five samples taken over a 30-day period, the fecal coliform bacterial level should not exceed a log mean of 200 per 100 ml nor should more than 10% of the total samples taken during any 30-day period exceed 400 per 100 ml.

Since combined sewer overflow and separate stormwater runoff both have very high fecal coliform concentrations, it was assumed that any nondisinfected discharge from these two sources will exceed the above criteria. Therefore, a high level of control will be required to meet this water quality objective. Treatment of all but two overflow events per year was selected as the basis for estimating facility needs to meet the recreation receiving water quality objective.

The incremental cost to achieve the recreation water quality objective (i.e., waters safe for full body contact) beyond the cost to protect fish and wildlife is $14.8 billion for Category V and $32.5 billion for Category VI. The costs reported in this 1978 Needs Survey depend upon the water quality criteria adopted to achieve the recreation water quality objectives. As discussed in Chapter 2, there is considerable uncertainty related to selection of bacteriological quality criteria for urban stormwater runoff and combined sewer overflow. Considering the magnitude of the incremental needs, additional research in the field of bacteriological contamination risks is warranted.

CONTROL TECHNOLOGIES

Alternative technologies for the control of combined sewer overflow and urban stormwater runoff are categorized into: (1) source controls, (2) collection system controls, and (3) treatment facilities.

To control pollutants at their source, management practices must be applied where pollutants accumulate. Streetsweeping and combined sewer flushing are examples of such techniques.

Collection system controls are implemented to provide maximum transmission of flows for treatment and disposal while minimizing overflow, bypass, and local flooding. Flow reduction, sewer separation, and inline storage are techniques used for control in the collection system. Flow reduction minimizes infiltration and inflow and requires a thorough analysis of the existing sewer system. Sewer separation may be a cost-effective control alternative for small watersheds. Inline storage reduces the amount of overflow and may utilize remote combined sewer system monitoring and control as well as real time control. The capital costs and annual operation and maintenance costs of these control systems are site-specific and could not be evaluated on a national basis in this project.

Treatment facilities considered include the following.

1. Offline storage.
2. Sedimentation.
3. Dissolved air flotation.
4. Screens and microscreens.
5. High-rate filtration.
6. Swirl and helical concentrators.
7. Chemical additions.
8. Coagulation and flocculation.
9. Biological treatment.
10. High-gradient magnetic separation.
11. Carbon adsorption.
12. Disinfection.
13. Sludge disposal.

Information on capital and operation and maintenance costs as well as on process pollutant removal efficiencies are required for a given technology in order to be considered in the national needs estimate. Such information is available for most but not all of the above technologies. Based on available information, the following physical/chemical treatment processes appear to be the most cost effective and were utilized as a basis for estimating the cost of treatment facilities.

1. Microscreen (23-micron).
2. Flocculation-sedimentation.
3. High-rate filtration.
4. Dissolved air flotation (with prescreening and chemical addition).

Offline storage, along with the above treatment processes were used to define five treatment trains which obtain maximum pollutant removal at least cost. These treatment trains are illustrated in Chapter 5. Application of the Needs Estimation Program (Appendix D) indicates that it is cost effective in general to provide significant amounts of storage as opposed to relying on high-rate treatment systems during the runoff period. If storage sites are not available, alternative treatment methods may be cost effective (Chapter 3); the Needs Estimation Program, however, assumes the availability of storage/treatment sites at the stated costs. The storage/treatment systems associated with the $25.7 billion estimate for the control of pollution from combined sewer overflow, Category V, amounts to 62 billion gallons of storage for Urbanized Areas, with a mean dewatering time for a full storage facility of 4.5 days. Similarly, the storage/treatment systems associated with the $61.7 billion estimate for the control of pollution from urban stormwater runoff, Category VI, amounts to 800 billion gallons of storage nationally, with a mean dewatering time for a full storage facility of 6 days.

Production theory, along with marginal cost analysis, was used to identify the optimum mix of source controls and storage/treatment facilities required to achieve a desired pollutant removal.

Production functions which define a relationship between level of effort and pollutant removal were developed from the literature. Sufficient information is available to define production functions for streetsweeping, sewer flushing, and storage/treatment systems.

The results of this investigation, including application of the Needs Estimation Program (Appendix D), indicate that there is no single best technology for the control of combined sewer overflow or urban stormwater runoff which is applicable to all situations. The required treatment level and optimum mix of control technologies varies from city to city. The procedure used to determine the optimum mix of pollution control technologies is presented in Chapter 9.

SITE STUDIES

Site studies were conducted in order to develop information related to receiving water impacts of CSO and urban stormwater runoff and information related to the economic optimization of facilities to control pollution from these sources. Therefore, the site studies consisted of two relatively independent phases. Phase I utilized continuous hydrologic simulation to evaluate receiving water impacts of all major pollution sources in selected urban areas and Phase II utilized production theory and marginal cost analysis to identify optimum control technologies. This information was then used to develop transferable principles and relationships which were used in the estimation of national needs.

The three main objectives of the receiving water impact site studies were to: (1) determine if a particular urban area/ receiving water system is presently exhibiting a water quality problem, (2) determine how much of the problem, if any, is due to CSO and stormwater runoff, and (3) determine the level of pollutant removal required to achieve selected water quality goals.

The water quality response of a receiving stream depends not only on the quantity and quality of stormwater runoff but also on the quantity and quality of upstream flow as well as point sources of pollution. These sources of pollutants and flow are largely independent and are made up of random or stochastic components. Thus, receiving water quality is the total effect of several random processes. Interactions among these processes cannot be represented adequately when addressed from the standpoint of a single isolated rainfall/runoff event with discharge to assumed or selected receiving water flow conditions. All events as they occur in nature should be considered. In order to accomplish this objective, continuous hydrologic/water quality simulation is required.

The "Continuous Stormwater Pollution Simulation System" (CSPSS) was developed specifically for use in the receiving water impact portion of the site studies. CSPSS is a computer-based probabilistic simulation model of an urban area receiving water system and will generate long-term synthetic records of (1) rainfall, (2) runoff, (3) runoff quality, (4) upstream receiving streamflow, (5) excess sewer system infiltration, (6) dry-weather (point source) waste discharges, and (7) receiving water quality response. In addition, the simulation will account for storage and treatment of urban runoff, including combined sewer overflow. Model components utilize Monte Carlo and Markovian techniques to produce random observations of variables where possible. The model will simulate, on a long-term basis the operation of alternative storage/treatment schemes and will provide stochastic information on overall reduction of loadings and on frequency and magnitude of overflow. Overflow events are then analyzed by the receiving water response portion of the model to determine stochastic relationships between frequency and magnitude of water quality violations and the size of storage and treatment facilities. Once such information is known, appropriate pollutant removal requirements can be selected based on the receiving water quality desired.

Ten sites served by combined sewer systems were selected for study, as follows.

Philadelphia, Pennsylvania
Atlanta, Georgia
Portland, Oregon
Rochester, New York
Bucryus, Ohio
Des Moines, Iowa
Milwaukee, Wisconsin
Washington, D.C.
Sacramento, California
Syracuse, New York

Five additional sites served by separate storm sewers were also selected for study, as follows.

Durham, North Carolina
Castro Valley, California
Springfield, Missouri
Tulsa, Oklahoma
Ann Arbor, Michigan

Phase I site study results identified the pollutant removal requirements for four indicator pollutants, suspended solids (SS), ultimate oxygen demand (UOD), dissolved lead (Pb), and phosphorus (P), at each study site where the indicator pollutant was applicable. The following is a summary of the results for SS and UOD removal requirements to meet the fish and wildlife water quality objective.

Summary of Pollutant Removal Requirements
Resulting from Site Studies

	Combined Sewer Sites		Urban Stormwater Runoff Sites	
Pollutant	Range	Mean	Range	Mean
SS	0%-91%	57%	41%-97%	81%
UOD	0%-93%	67%	0%-30%	9%

Six of the study sites indicate that some lead removal is required to meet the selected criteria. Long-term dissolved lead levels for four of these six sites are dominated by the receiving water background concentrations; hence, removal of lead from CSO and urban stormwater runoff is not justified. Selection of a treatment level which will provide the required suspended solids removal for the other two sites will also provide for the required lead removal. Therefore, lead removal requirements were not directly considered in estimation of the needs for CSO and urban stormwater runoff.

Although no nationally applicable method for estimating lead removal requirements could be obtained from the results of the site studies, several conclusions regarding dissolved lead impacts can be made.

1. Our understanding of dissolved lead toxicity in natural waters is inadequate to establish justifiable limits. Much additional research on both acute and chronic lead toxicity for a number of representative species is required.

2. The data base on which background receiving water lead concentrations are determined is inadequate. Background lead has been shown to dominate the system at four of the six study sites which indicate a potential dissolved lead problem. Data which define background receiving water lead concentrations are few and quite variable.

3. Receiving waters with background hardness greater than approximately 250 mg/l are unlikely to experience dissolved lead toxicity problems.

4. Design of stormwater management systems based on the suspended solids and dissolved oxygen criteria outlined in this report

will result in substantial watershed lead removals. Additional removals, if any, necessary to obtain acceptable receiving water dissolved lead concentrations are indeterminate at this time.

One study site discharges directly to a lake and a phosphorus removal requirement of 80% from the CSO portion of the load is indicated. However, wastewater treatment plant effluent, not CSO, is the predominant source of phosphorus pollution.

The most cost-effective combination of control alternatives for achieving any desired level of pollutant removal was established by the economic optimization (Phase II), which is based on marginal cost analysis and production theory. Streetsweeping, sewer flushing, and storage/treatment are the three control options considered.

In stormwater pollution control, the objective is to remove pollutants from the receiving water. The objective of the economic analysis is to identify the most cost-effective mix of streetsweeping, sewer flushing, and storage/treatment systems which will achieve various levels of pollutant removal.

The technique is used to determine control alternatives to achieve any desired level of BOD_5 or SS removal from three basic watershed categories. The three watershed categories are (1) watersheds with only combined sewer overflow (CSO), (2) watersheds with only stormwater runoff (SWR), and (3) watersheds with both CSO and SWR. The four study sites selected to represent these watershed categories are: (1) Castro Valley, California (SWR only), (2) Bucyrus, Ohio (CSO only), (3) Des Moines, Iowa (both CSO and SWR), and (4) Milwaukee, Wisconsin (both CSO and SWR). All three of the selected control options were analyzed on the CSO watersheds and streetsweeping and storage/treatment were analyzed on the stormwater runoff watersheds.

A complete tabulation of the optimum total costs and pollutant removals by watershed and control option is presented in Chapter 9.

The results of the economic optimization indicate that it is generally more cost-effective to employ a mix of technologies rather than a single technology. Furthermore, source controls are generally most useful when overall pollutant removal requirements are low and storage/treatment systems are most useful when overall pollutant removal requirements are high.

NEEDS ESTIMATE

The combined sewer data used in the estimation of the 1978 needs were obtained by establishing the National Combined Sewer System Data File, which includes the location, sewer system and receiving water characteristics, and the status of CSO planning for each identified combined sewer system in the nation.

The actual data were collected by Dames and Moore, Inc., using guidelines provided by CH2M HILL. The resulting data file contains information on 1,143 combined sewer systems nationwide.

Data from the National Combined Sewer System Data File were used in part to establish the Urbanized Area Data Base, which is used directly in the estimation of Categories V and VI needs.

As of 1 January 1978, there were 279 Urbanized Areas defined in the nation. Thirty-five of the Urbanized Areas encompassed area in two states and three Urbanized Areas encompassed area in three states. By subdividing the Urbanized Areas by state, a total of 320 areas were defined for estimation of Categories V and VI needs.

The Urbanized Area Data Base consists primarily of the following items.

1. Demographic data.
   a. The items in this category are the combined sewer service area and the population served by combined sewers, the Urbanized Area population and size, the year 1970 SMSA population and year 2000 SMSA population estimate, and the citywide EPA construction cost factor.
2. Hydrologic data.
   a. The items in this category are the number of days with rain per year, the mean annual rainfall, the receiving water classification, the mean annual flow of the receiving water, and the natural runoff coefficient.
3. Water quality data.
   a. The items in this category are maximum monthly receiving water temperature; background BOD, suspended solids lead, hardness, alkalinity, and pH of the receiving water.

The Non-Urbanized Area Data Base, similar to the Urbanized Area Data Base, was also developed to estimate the needs for the combined sewer systems located outside of the Bureau of Census-defined Urbanized Areas.

A needs estimation computer program for Categories V and VI developed for the 1978 Needs Survey calculates present and year 2000 capital and operation and maintenance costs for the aesthetics level, the fish and wildlife level, and the recreation level.

The SS and BOD_5 removal requirements for the fish and wildlife objective were computed and an estimate of the optimum mix of pollutant removal by sewer system type was obtained. The level of effort, pollutant removal, and cost of management practices were then computed, followed by selection of an appropriate treatment level and, finally, establishment of the required annual pollutant capture. The optimum combination of storage volume and treatment rate was then determined. This storage/ treatment cost minimization, together with the use of appropriate management practices, is the basis of the economic optimization of facility needs to meet the fish and wildlife water quality objective. Pollutant removal determinations, selection of control technologies, levels of effort, and facility sizes are based on the results of the site studies.

Needs for the recreation objective are based on treatment and disinfection of nearly all combined sewer overflow and urban stormwater runoff in order to eliminate bacterial contamination from these sources. An allowable discharge of two untreated overflow events per year has been selected as the basis for estimating facility needs.

Needs estimates for the year 2000 are based on the assumption that no new combined sewer systems will be constructed and that all population growth will occur in the separate sewer service area. Therefore, year 2000 Category V needs are equal to present Category V needs.

It is further assumed that existing population densities will remain constant and that new growth will be accommodated by an increase in urbanized land area and not by an increase in population density. Based on these assumptions, Urbanized Area characteristics in the year 2000 are computed and a needs estimate for these conditions was developed.

A sensitivity and correlation analysis performed on the Urbanized Area needs estimates for Categories V and VI indicate that the development of a more reliable needs estimate will depend upon development of more reliable information on almost all aspects of the problem. This analysis also indicates that needs for a given municipality are highly correlated with land area and number of persons served.

PART I

NEEDS SURVEY OBJECTIVES

BACKGROUND

The Federal Water Pollution Control Act Amendments of 1972, PL 92-500, requires the United States Environmental Protection Agency (EPA) to estimate the needs of publicly owned treatment facilities to meet the 1983 water quality requirements of PL 92-500. Section 516(b) of PL 92-500 requires EPA to make a detailed estimate of individual State needs as well as total national needs for the construction of all publicly owned treatment works. The national needs survey is to be completed biennially and submitted to Congress not later than 10 February of each odd numbered year. This report presents the 1978 estimate of needs for control of pollution from combined sewer overflow and urban stormwater runoff as well as a description of the criteria, methods, and assumptions used to develop the needs estimates.

PREVIOUS NEEDS ESTIMATES

The first comprehensive needs survey was the 1973 Survey of Needs for Municipal Wastewater Treatment Facilities. The 1973 Needs Survey focused on the needs to achieve the 1977 requirements of PL 92-500. The needs were determined for five categories: I - Secondary Treatment, II - More Stringent Treatment, III - Infiltration/Inflow Correction, IVa - New Interceptor Sewers, IVb - New Collector Sewers, and V - Combined Sewer Overflow Correction. Identified needs totaled $60.123 billion. Needs for stormwater control and major sewer system rehabilitation were not included in the 1973 Needs Survey.

Even though EPA's final report on the 1973 Needs Survey was not submitted to Congress until November 1973, a new survey was needed in 1974 to meet the requirement of PL 92-500 for an updated report by 10 February 1975. Recognizing a need to address the cost for achieving the 1983 goals of PL 92-500 as well as the eligible costs for the treatment and/or control of stormwater, Congress, through passage of PL 93-243, required EPA to amend the 1973 survey approach to include these projects in the new needs survey.

The 1974 Needs Survey divided Category III into IIIa - Infiltration/Inflow Correction and IIIb - Major Sewer System Rehabilitation and added Category VI - Treatment and/or Control of Stormwaters. The subcategories of Category IV were renumbered so that all collectors were reported in Category IVa and interceptors were reported in Category IVb. A limited amount of time was available for the states and local authorities to complete the 1974 Needs Survey. During mid-May 1974, regional meetings were conducted by EPA to provide the States with guidance, including instructions on preparation of Category VI needs for the treatment and/or control of stormwaters. The time restrictions for the survey required the states to submit a summary report by 26 July 1974 and a final State report by 20 August 1974. Also, EPA was required to supply Congress with a preliminary report by 3 September 1974.

The results of the 1974 Needs Survey showed that needs to meet the objectives of Categories I through IV totaled $76.360 billion. The estimated needs for Categories V and VI were $31.076 billion and $235.006 billion, respectively. The reported costs for Category V in 1974 increased by some 245% over those in 1973. Both surveys considered needs for the projected 1990 population and reported in June 1973 dollars.

EPA provided specific guidance to the States and municipalities for Categories I through IV. Some guidance was available for Category V and only general guidance was presented for Category VI. However, the results were to be used as a basis for allocating federal funds and varying methods and assumptions were utilized which impacted the results of the needs estimates. These variations in methods, assumptions, and results identified a need for a uniform technique to be applied nationwide.

Under authority of Section 315 of PL 92-500, the National Commission on Water Quality (NCWQ) developed an independent survey to estimate the costs of achieving the requirements of PL 92-500 for publicly owned treatment works. This nationwide assessment involved four basic steps: 1) an identification of needed facilities and applicable technologies, 2) a determination of available technologies likely to be used and their costs, 3) an assignment of available technologies to individual needs, followed by 4) addition of costs. A similar approach was taken in estimating quantities of residual wastes generated and requirements for manpower, energy, materials, and land. The NCWQ survey resulted in a range of cost estimates for control of pollution from combined sewer overflow and urban stormwater runoff, depending on the level of control achieved. The NCWQ investigation did apply a uniform set of assumptions criteria and methods nationwide and did, therefore, correct some of the deficiencies of the 1974 needs survey.

The 1976 Needs Survey was conducted by EPA under contract with several consultants. Separate contracts for Categories I through IV and for Categories V and VI were let. Like the NCWQ Study, the 1976 Needs Survey for Categories V and VI also employed a uniform set of assumptions, criteria, and methods to develop the nationwide estimates. In addition, the assimilative capacity of the receiving water was considered in the establishment of pollutant removal requirements.

Unlike previous surveys, the 1976 needs estimates for Categories V and VI were developed for three different receiving water quality objectives: 1) aesthetics, 2) fish and wildlife, and 3) recreation. Thus, state-by-state needs were associated with various levels of receiving water use.

A summary of the results of previous capital cost estimates for control of pollution from combined sewer overflow and urban stormwater runoff is presented in Table 1-1. These results include the 1973 Needs Survey, the 1974 Needs Survey, the NCWQ estimate, and the 1976 Needs Survey. All costs are updated to January 1978 dollars for direct comparison with the cost estimates developed in this, 1978 Needs Survey Report.

1978 NEEDS SURVEY OBJECTIVES

The major objective of this project is to develop updated nationwide cost estimates on a State-by-State basis for control of pollution from combined sewer overflow (Category V) and urban stormwater runoff (Category VI). The term "State" as used in this report shall include all 50 States, the District of Columbia, American Samoa, Guam, Puerto Rico, Trust Territories (including Wake Island), and the Virgin Islands.

The cost estimates for the above two categories are divided into the following six divisions for each State.

1. Current Year Capital Needs, Category V--Capital costs needed to fund alternatives, sized for the current metropolitan development pattern, to control selected pollutants in combined sewer overflow.

2. Operation and Maintenance Costs, Category V--Annual equivalent operation, maintenance, and repair cost during 20-year planning period for alternatives to control selected pollutants in combined sewer overflow.

3. Year 2000 Needs, Category V--Capital costs needed to fund alternatives, sized for the year 2000 metropolitan development pattern, to control selected pollutants in combined sewer overflow.

4. Current Year Capital Needs, Category VI--Capital costs needed to fund alternatives, sized for the current metropolitan development pattern, to control selected pollutants in urban stormwater runoff.

5. Operation and Maintenance Costs, Category VI--Annual equivalent operation, maintenance, and repair costs during 20-year planning period for alternatives to control selected pollutants in urban stormwater runoff.

Table 1-1
Comparison of Previous Capital Cost Estimates for Control of Pollution from Combined Sewer Overflow and Urban Stormwater Runoff

	Capital Cost in Billions of January 1978 Dollars			
Category	1973 Needs Survey	1974 Needs Survey	NCWQ Report[a]	1976 Needs Survey[b]
V--Combined Sewer Overflow	17.9	43.8	5.9-96.4	6.5, 14.0, 21.2
VI--Urban Stormwater Runoff	--	331.2	64.8-491.8	23.7, 58.7, 62.8
Total	--	375.0	70.7-588.2	30.2, 72.7, 84.0

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[a] Range indicates various control levels.

[b] Values are for aesthetics, fish and wildlife, and recreation receiving water quality criteria, respectively, for year 1990 conditions. Values for Category VI are for census defined Urbanized Areas only.

6. Year 2000 Needs, Category VI--Capital costs needed to fund alternatives, sized for the year 2000 metropolitan development pattern, to control selected pollutants in urban stormwater runoff.

An additional objective of this project in conjunction with the Category I through IV portion of the needs survey is to establish a National Combined Sewer System Data File. This file contains information on every known combined sewer system in the nation, including location, sewer system characteristics, receiving water characteristics, and the status of current CSO correction planning. This data base is described in Chapter 11 and is used in part to estimate Category V needs.

1978 NEEDS SURVEY METHOD

The approach taken in the 1978 Needs Survey for Categories V and VI is in many ways similar to the approach taken in the 1976 Needs Survey. Both investigations developed cost estimates for achieving three levels of receiving water quality, the aesthetics level, the fish and wildlife level, and the recreation level. Both investigations considered the assimilative capacity of the receiving water in the determination of pollutant removal requirements. Finally, both investigations utilized specific site studies to determine the interactions of an urban area, its pollutant production characteristics, and receiving water quality.

The major differences between the 1976 Needs Survey approach and the 1978 Needs Survey approach are specific improvements of the 1976 method. The major improvements include: 1) development of probabilistic wet-weather receiving water quality criteria, 2) development and application of a continuous stochastic urban runoff and receiving water response simulation model for the purpose of estimating pollutant removal benefits and requirements at the study sites, and 3) application of production theory and marginal cost analysis in order to determine the optimum mix of structural and nonstructural pollution abatement controls. These major technical improvements along with the development of an expanded combined sewer data base significantly improve the quality of the 1978 needs estimate for Categories V and VI.

The 1976 Needs Survey approach utilized a single "design storm" simulation to estimate receiving water quality response, whereas the approach for the 1978 Needs Survey utilizes continuous hydrologic simulation. As part of this project, a linked rainfall/runoff receiving water response model known as the "Continuous Stormwater Pollution Simulation System" was developed for use in the site studies. This model is briefly described in Chapter 7, and a user manual (FRD-4) has been prepared as a separate volume. The model can be used to simulate the water quality response of a one dimensional receiving stream to intermittent combined sewer overflow (CSO) and urban stormwater runoff (SWR) as well as upstream river flow and wastewater treatment plant (WWTP) effluent on a long-term continuous basis. In this manner, the water quality effects of changes in any of the pollutant sources can be estimated. Continuous simulation is a conceptually more realistic representation of the behavior of stormwater/water quality response systems than is the single event simulation used in 1976.

Once the pollutant removal requirements were determined based on the selected receiving water quality criteria and on the results of the continuous simulation, control alternatives, and their costs were developed. The 1976 approach did not provide for identification of optimum pollution control strategies; whereas, the approach utilized for 1978 provides for the selection of optimum mix and sizing of control alternatives.

The information obtained from the 15 site studies, including the economic optimization, is utilized in a manner similar to the 1976 approach for the development of the actual cost estimates. An Urbanized Area data base, also enhanced, expanded, and updated from the 1976 version, is utilized along with updated cost equations to develop a needs estimate for each Urbanized Area for both Categories V and VI. In addition, needs estimates are developed for all combined sewer service areas located outside of Urbanized Areas. The overall approach is similar to the 1976 method although the details of many calculations have been changed. The computation procedure is described in Chapter 12.

Chapter 2
RECEIVING WATER QUALITY OBJECTIVES

INTRODUCTION

The purpose of this chapter is to develop criteria for the evaluation of receiving water impacts due to combined sewer overflow and urban stormwater runoff. Receiving water quality criteria must be developed in order to evaluate the need for control of pollution from stormwater and other sources. Any criteria selected will be arbitrary to some extent. However, without such criteria, a "needs estimate" cannot be developed.

The selection of pollutants to be controlled and the establishment of receiving water quality criteria for these pollutants may be viewed as the formulation of abatement objectives. Abatement objectives or overall pollution control goals are not only technical questions but are also policy and management questions.

The water quality criteria are developed on a probabilistic basis. That is, in addition to the selection of a numeric limit for a given water quality parameter, an allowable frequency of exceedance of this limit is also specified. The water quality criteria are also developed on a national basis as was done in the 1976 Needs Survey, but the actual numeric limits may vary with geographic location and with background receiving water quality.

Criteria are developed for three levels of water quality: (1) aesthetics, (2) fish and wildlife, and (3) recreation. Total dollar needs to achieve each of these levels of water quality are developed, based in part upon the selected receiving water quality objectives. These dollar estimates are presented in Part IV, "Needs Estimate," of this report.

INDICATOR POLLUTANTS

Since it is impossible to consider all pollutants which may enter a receiving water via combined sewer overflow and urban stormwater runoff, indicator pollutants must be selected for evaluation and control.

The indicator pollutants which vary by receiving water quality objective, are listed as follows.

1. Aesthetics objective.
    a. Floatable solids.

    - b. Settleable solids.

2. Fish and wildlife objective.
    - a. Suspended solids.
    - b. Carbonaceous BOD (BOD_5).
    - c. Nitrogenous BOD (TKN).
    - d. Dissolved lead.
    - e. Total phosphorus (for lakes).
3. Recreation objective.
    - a. Suspended solids.
    - b. Carbonaceous BOD (BOD_5).
    - c. Nitrogenous BOD (TKN).
    - d. Dissolved lead.
    - e. Total phosphorus (for lakes).
    - f. Fecal coliforms.

For practical purposes, the above list represents the pollutants for which reasonable estimates of pollutant washoff and receiving water impact may be developed. Other materials such as pesticides or heavy metals other than lead may potentially require control; however, not enough is known about their occurrence in the urban system to evaluate potential impacts.

Inclusion of a pollutant in the above list does not necessarily mean that removal of that pollutant will actually impact the magnitude of the needs estimate. It does mean, however, that the above pollutants are considered in the formulation of receiving water quality criteria and that receiving water impacts are evaluated in the 15 site studies.

AESTHETICS OBJECTIVE

The following criteria were applied to the aesthetics objective in the 1976 Needs Survey.[1]

> "All waters are to be aesthetically compatible to adjacent areas. All waters shall be free from oil, scum, and floating debris associated with cultural activities in amounts sufficient to be unsightly.

> "All waters shall be free from materials associated with cultural activities which will settle and form significant sediment or sludge deposits that become unsightly or interfere with stream capacities."

Criteria proposed by EPA in "Quality Criteria for Water" for the aesthetics level are:[2]

> "All waters free from substances attributable to wastewater or other discharges that:
>
> 1. settle to form objectionable deposits;
> 2. float as debris, scum, oil, or other matter to form nuisances;
> 3. produce objectionable color, odor, taste, or turbidity;
> 4. injure or are toxic or produce adverse physiological responses in humans, animals, or plants; and
> 5. produce undesirable or nuisance aquatic life."

The above two sets of criteria are essentially the same and provide a baseline or minimal requirement for freedom from pollution. The EPA criteria has been adopted as the goal of the aesthetics objective in the 1978 Needs Survey.

Specific quantitative values are not associated with the aesthetics objective which implies a minimum technology-based level of control for all combined sewer overflow and urban stormwater runoff.

FISH AND WILDLIFE OBJECTIVE

The suitability of a receiving water body for propagation of fish and wildlife is largely a function of in-stream water quality. However, other factors such as the variability of the flow will affect suitability. For example, if a stream or lake is dry during certain portions of the year, then it cannot be expected to maintain a viable fishery even if the water quality is very good.

Dissolved oxygen concentration is one of the most important indicators of the ability of a water body to support a well-balanced aquatic fauna. Urban areas adversely affect the DO resources of a water body by introduction of carbonaceous oxygen demand (CBOD) and nitrogenous oxygen demand (NBOD) during periods of wet weather. Therefore, the combined effects of these two pollutants may be evaluated by considering the DO budget of the receiving stream.

Excess suspended solids will also adversely affect the suitability of a stream to support a viable fishery. The extent of this effect is to a large degree a function of the background or natural suspended solids load carried by the receiving water.

Toxic materials such as heavy metals and pesticides may have undesirable effects on the aquatic life of a water body. Lead is one heavy metal which has been associated with urban runoff largely due to the current use of leaded gasoline.

In the case of lakes, overenrichment with nutrients such as nitrogen and phosphorus will cause excessive growth of undesirable aquatic weeds and algae which will interfere with the natural fishery. This process, when induced by nutrients added by man, has been termed cultural eutrophication. In some cases, the algae will produce large diurnal fluctations in dissolved oxygen which will also reduce the ability of the lake to maintain a balanced fishery. In extreme cases, an algal bloom may be generated which will eventually die and exert a short-term oxygen demand which depletes the oxygen resource and results in a fishkill.

It has been shown that, in most cases, phosphorus is the growth-limiting nutrient and that control of phosphorus will result in the control of cultural eutrophication.

Dissolved Oxygen (DO)

The dissolved oxygen criteria proposed by EPA in "Quality Criteria for Water" for freshwater aquatic life are given as follows.

> "Freshwater aquatic life: A minimum concentration of dissolved oxygen to maintain good fish populations is 5.0 mg/l. The criterion for salmonid spawning beds is a minimum of 5.0 mg/l in the interstitial water of the gravel."

Most states have established fish and wildlife standards which are in substantial agreement with the criteria suggested above. Many states differentiate between cold water species (i.e., salmonids) and warm water species. The most often cited limit for cold water species is 6.0 mg/l, whereas the limit for warm water species is 5.0 mg/l.

The above limits define the lower end of the DO range at which a healthy fish population can be maintained. However, DO concentrations as low as 2 to 3 mg/l can be tolerated infrequently for short durations without causing fishkills. Therefore, it appears to be appropriate to establish a minimum DO limit and an allowable frequency of exceedance of selected DO limits.

Conventional wastewater treatment plant design is based on an analysis of the DO budget of the receiving water during low flow conditions. The generally accepted criterion is to maintain a DO level at or above the minimum level during the 7-day, 10-year low flow event, defined as that low flow rate which will occur for 7 consecutive days an average of once in any given 10-year period. Thus, facility needs for the conventional wastewater treatment plant are defined by a receiving water impact analysis whereby the required degree of treatment is based on maintaining a minimum DO level at all times except during extreme low flow conditions; Thus, an allowable frequency of exceedance of water quality criteria is incorporated into the design; and therefore, the cost of facilities for the control of pollution from municipal wastewater.

The intent of the fish and wildlife objective is to provide a receiving water suitable for the propagation of fish and wildlife and to prevent severe and/or frequent man-induced fish kills. A viable fishery can be maintained if the DO level is generally above 5.0 mg/l, and fish kills will occur only if the DO drops to low levels for significant durations and the fish are unable to move to another part of the water body where DO levels are higher. From available data[3], a relationship between safe and lethal levels of DO for various durations has been developed and is illustrated on Figure 2-1. This DO level duration relationship is based on measured survival times of Juvenile Brook Trout when subjected to lethal levels of DO. Juvenile Brook Trout are a very sensitive indicator species. Therefore, the relationship shown in Figure 2-1 is conservative for most receiving waters. The selected criteria based on the relationship given in Figure 2-1 and on "Quality Criteria for Water" are given as follows.

> The minimum receiving water dissolved oxygen concentration shall not average less than 2.0 mg/l for more than 4 consecutive hours; nor shall the minimum receiving water dissolved oxygen concentration average less than 3.0 mg/l for more than 72 consecutive hours (3 days). In addition, the annual average receiving water dissolved oxygen concentration shall be greater than 5.0 mg/l for all waters which will support warm water species and shall be greater than 6.0 mg/l for all waters which will support cold water (salmoid) species.

The results of the simulation studies, which are discussed in Chapters 8 and 10, indicate that, if the 2.0 mg/l for 4 consecutive hours criterion is met, then, in general, all other criteria are met. That is, this criterion, in most cases, controls the level of BOD removal required. If this condition occurs infrequently and for short durations, then only a small volume of water will be affected and fish kills will be unlikely. That is, the fish will be able to escape the small volume of poor quality water during the time of minimum DO level. For this reason, an allowable frequency exceedance of the 2.0-mg/l criteria of one 4-hour period per year has been selected as the basis for establishment of BOD removal requirements.

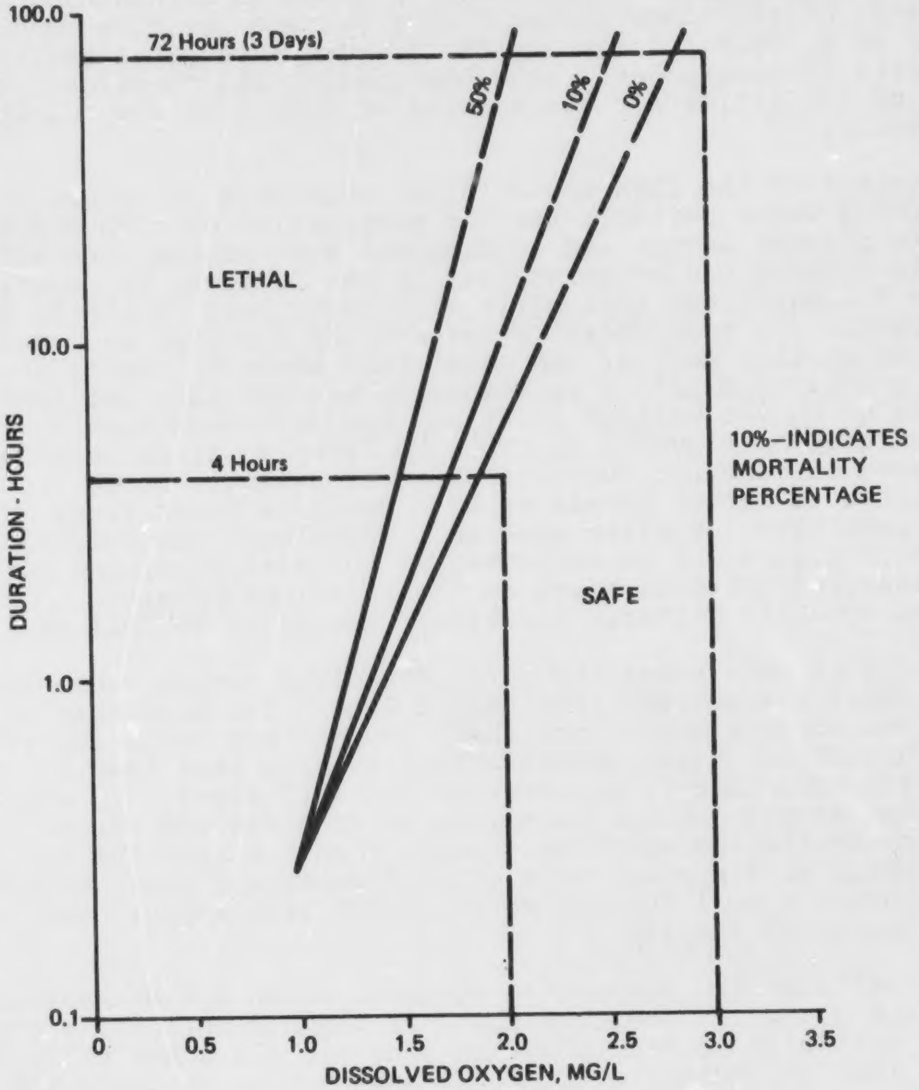

FIGURE 2-1. Mortality of Juvenile Brook Trout due to low DO levels.

It should be noted that, in some cases, the DO criteria for the fish and wildlife objective cannot be met even if all pollutants are removed from the combined sewer overflow and urban stormwater runoff. In these cases, removal requirements are based on elimination of 90% of the occurrences of low DO (i.e., <2.0 mg/l) which can be controlled. For example, if a receiving water is subject to 100 occurrences per year of mean 4-hour DO less then 2.0 and if removal of all BOD from urban stormwater runoff and CSO will reduce the number to 70 per year, BOD removal requirements will be based on elimination of 27 of the 30 controllable low DO events.

Suspended Solids (SS)

The solids (suspended and settleable) and turbidity criteria proposed by EPA in "Quality Criteria for Water" for freshwater fish and other aquatic life are given below.

> "Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life."

The above criteria are difficult to interpret from the standpoint of establishment of numeric limits above which the aquatic environment will be harmed. However, the philosophy proposed is to base the receiving water standard on the background or natural water quality. That is, receiving waters with high natural turbidity are considered to be relatively insensitive to added suspended material, whereas receiving waters with low natural turbidity are considered to be sensitive to added suspended materials. This sensitivity is measured as a function of light penetration.

It has been shown that light penetration in north Florida lakes is inversely and linearly related to color and turbidity.[4] That is, if other factors are constant, light penetration and, therefore, photosynthetic activity may reasonably be assumed to be inversely proportional to turbidity.

It is well known that suspended solids concentrations affect turbidity and that an increase in suspended solids will result in an increase in turbidity. Turbidity is an optical property that causes light to be scattered and absorbed rather than transmitted in straight lines. This scattering of light is caused by the presence of suspended matter. Attempts to develop general correlations between suspended matter and turbidity have proved impractical because the size, shape, and refractive index of the particles are important and vary from place to place.[5]

The European Inland Fisheries Advisory Commission reviewed the effects of suspended solids on fish in 1965.[6] This study resulted in the following conclusions relating to inert solids concentrations and satisfactory water quality for fish life.

1. There is no evidence that concentrations of suspended solids less than 25 mg/l have any harmful effects on fisheries.
2. It should usually be possible to maintain good or moderate fisheries in waters which normally contain 25 to 80 mg/l suspended solids. Other factors being equal, however, the yield of fish from such waters might be somewhat lower than with less than 25 mg/l.
3. Waters normally containing from 80 to 400 mg/l suspended solids are unlikely to support good freshwater fisheries, although fisheries may sometimes be found at the lower concentrations within this range.
4. At best, only poor fisheries are likely to be found in waters which normally contain more than 400 mg/l suspended solids.

The Commission report also stated that exposure to several thousand mg/l for several hours or days may not kill fish and that other inert or organic solids may be substantially more toxic.

Based on the above review of suspended solids and their effects on freshwater aquatic life, the selected criteria for evaluation of facility needs for control of pollution from combined sewer overflow and urban stormwater runoff to achieve the fish and wildlife receiving water quality goal are stated as follows.

> "The mean value of suspended solids concentration discharged to the receiving water from urban stormwater and CSO sources should not exceed the mean value of natural background suspended solids concentration for the subject receiving water on an annual basis."

The above general criteria will apply except in cases where the allowable mean value of suspended solids concentration is less than 25 mg/l. In this case, a discharge limit of 25 mg/l shall apply. This exception is based on the conclusion reached in the European Inland Fisheries Advisory Commission study that concentrations of suspended solids less than 25 mg/l have no harmful effects on fisheries.

Dissolved Lead (Pb)

The dissolved lead criteria proposed by EPA in "Quality Criteria for Water" for freshwater fish are given below.

> "0.01 times the 96-hour LC_{50} value, using the receiving or comparable water as the diluent and soluble lead measurements (using an 0.45 micron filter), for sensitive freshwater resident species."

Like the suspended solids criteria, the above criteria are also difficult to interpret from the standpoint of establishment of numeric limits above which the aquatic environment will be harmed. The toxicity of lead in water is affected by pH, hardness, organic materials, and the presence of other metals. In addition, the solubility of lead in water is a function of pH, alkalinity, and hardness and varies over several orders of magnitude.

As much as 5,000 tons of total lead per year may be added to the aquatic environment as a result of urban runoff.[2] However, it is not known how much of this total is in the dissolved state. One study of an urban watershed in central Illinois reports that only about 10% of the lead washoff is soluble.[7] The remainder is associated with solids and eventually ends up in the sediments and not in the water column.

This same study[7] also reports that ingestion is not a primary mode of lead uptake in fish. When fish (creek chubs) were fed foods with high lead content for 25 days, the body burden was not increased. On the other hand, when fish (channel catfish) were exposed to lead in solution, accumulation rates and final body burdens were correlated to initial solution concentrations. Thus, in order for fish to accumulate lead, it must be present in soluble form in the water column.

The lead criteria proposed by EPA[2] imply that only the soluble fraction of aquatic lead is of concern. This conclusion is supported by the results of the Illinois study.

A summary of total lead toxicity data for fish is reported in "Quality Criteria for Water." Data on the 96-hour TL_m for various warm and cold water species are reported in Tables 2-1 and 2-2, respectively.

Inspection of the data presented in Tables 2-1 and 2-2 reveals that only one value of dissolved lead is reported in "Quality Criteria for Water." The summary data indicate that measurements of dissolved metals are not often made in acute toxicity bioassay testing. Thus, these data are of little value when the objective is to establish acute toxicity limits based on the dissolved fraction.

Davies[8] has reported results of both acute lead toxicity bioassays and chronic (long-term) lead toxicity bioassays for rainbow trout in which dissolved lead concentrations as well as total lead concentrations were measured. A summary of the acute toxicity data is given in Table 2-3.

Inspection of these data indicates that total lead, pH, alkalinity, and hardness vary over a wide range, whereas the dissolved lead fraction does not. Thus, it may be concluded (from this extremely limited data base) that the 96-hour TL_m for rainbow trout is approximately 1.32 mg/l of dissolved lead.

Table 2-1
Mean Total Lead Toxicity
Limits for Warm-Water Species
(96-hour TL_m's)

Species	96-hour TL_m Total Pb (mg/l)	pH	Alkalinity (mg/l)	Hardness (mg/l)
Bluegills	23.8	7.5	18	20
Bluegills	442	8.2	300	360
Flatheads	6.46	7.5	18	20
Flatheads	0.97	7.4	18	20
Flatheads	5.6	7.4	18	20
Flatheads	2.4	7.4	18	20
Flatheads	7.48	7.5	18	20
Flatheads	482	8.2	300	360

Note: Data are summarized from "Quality Criteria for Water."

Table 2-2
Mean Total and Dissolved Lead
Toxicity Limits for Cold-Water Species
(96-hour TL_m's)

Species	96-hour TL_m Total Pb (mg/l)	pH	Alkalinity (mg/l)	Hardness (mg/l)	Dissolved Pb (mg/l)
Rainbow trout	--	7.8	14	300	1.38
Rainbow trout	471	7.8	14	300	--
Rainbow trout	542	6.7	16	385	--
Brook trout	4.5	7.0	43	45	--
Brook trout	5.8	7.2	41	44	--
Coho salmon	0.8	--	--	22	--
Coho salmon	0.8	--	--	22	--
Coho salmon	0.52	--	--	22	--
Coho salmon	0.52	--	--	22	--

Note: Data are summarized from "Quality Criteria for Water."

Table 2-3
Summary of Acute Dissolved and Total Lead Toxicity Data for Rainbow Trout (Davies, 1976)

96-hour TL_m Dissolved Pb (mg/l)	96-hour TL_m Total Pb (mg/l)	pH	Alkalinity (mg/l)	Hardness (mg/l)
1.32	542	8.15	267	385
1.47	471	8.78	228	290
1.17	1.45	6.85	30	32

Analysis of the acute toxicity results reported by Davies also indicates that the dissolved lead concentration at which no kills were observed in 96 hours is approximately 0.33 mg/l dissolved lead. These values ranged from 0.22 mg/l to 0.48 mg/l. This value may be considered to be a threshold above which fishkills will begin to occur due to acute lead toxicity. Concentrations below this value should not result in fishkills if the duration of the concentration is 96 hours or less. These results indicated that a safe (no kills) limit for dissolved lead acute toxicity is approximately equal to 25% of the 96-hour TL_m value.

Davies' data on chronic toxicity indicate that safe levels for chronic effects are considerably lower than safe levels for acute effects. Chronic toxicity limits should, however, be applied to long-term average dissolved lead receiving water concentrations and not to peak short-term (i.e., 96-hour) concentrations. The no-effect dissolved lead limit for rainbow trout was determined to be approximately equal to 0.01 mg/l in soft water and 0.025 mg/l in hard water. The above limits were computed by averaging the values at which no chronic effects were observed with the minimum value at which chronic effects were first observed. The chronic effect observed in the Davies long-term experiments was the development of "black tails" on the sample fish. These experiments were conducted for a period of 19 months.

Based on the above discussion of dissolved lead toxicity, the following criteria for evaluation of facility needs for control of pollution from combined sewer overflow and urban stormwater runoff to achieve the fish and wildlife receiving water quality goal were selected.

1. The mean in-stream 96-hour (time averaged) dissolved lead concentration should not exceed 0.33 mg/l.

2. The long-term mean in-stream dissolved lead concentration should not exceed 0.01 mg/l in soft waters (hardness less than or equal to 100 mg/l) or 0.025 mg/l in hard waters (hardness greater than 100 mg/l).

The above criteria should prevent both fishkills (except for very rare occurrences) and long-term toxicity problems from developing. In order to apply the criteria, background water chemistry which affects lead solubility and background receiving water lead concentrations must be known. Background water chemistry for the nation's surface waters has been reported by McElroy et al.,[9] and generalized maps of pH, alkalinity and hardness are available. The major problems remain the definition of appropriate 96-hour TL_m values for dissolved lead for a variety of species and the quantification of natural background lead concentrations in the receiving stream.

Phosphorus (P)

The goal of nonpoint source water quality criteria for lakes should be to prevent cultural eutrophication. This goal is easy to state but somewhat difficult to quantify. This difficulty begins with the fact that the concepts of eutrophication and trophic state are subjective and thus do not have exactly the same meaning to any two individuals. The situation is further complicated by the fact that no single parameter can be used in all cases to measure trophic state.

There are three generally recognized levels of trophic state. These are: (1) oligotrophic, (2) mesotrophic, and (3) eutrophic. Oligotrophic lakes are characterized by clear waters and low primary productivity. Mesotrophic lakes represent an intermediate level and are generally characterized by good quality waters which support a highly diversified biological population and moderate production of algae. Eutrophic lakes tend to have high populations of rough fish and limited populations of game fish. They are subject to periodic algal blooms and/or excessive littoral vegetation. Such waters are of general lower quality than are noneutrophic lakes and tend to be subject to dissolved oxygen stress associated with algal blooms.

In general, phosphorus is the nutrient which limits the growth of algae. In cases where the water body is highly eutrophic, nitrogen is occasionally the limiting nutrient. However, for most cases, it may be assumed that control of phosphorus will result in control of eutrophication.

Freshwater phosphorus criteria are not selected in "Quality Criteria for Water." However, in the discussion of phosphate phosphorus, it is suggested that maximum concentrations in lakes be limited to 0.025 mg/l in order to prevent excessive or nuisance growth of algae or other aquatic plants. Larsen and Mercier[10] recommend that lake phosphorus concentrations be limited to 0.020 mg/l. This criterion is also based on the prevention of nuisance algae growth.

The following phosphorus criterion is selected for evalution of facility needs for control of pollution from combined sewer overflow and urban stormwater runoff to achieve the Fish and Wildlife receiving water quality goal.

> "Average annual lake phosphorus concentrations should not exceed 0.025 mg/l."

The evaluation procedure outlined by Larsen and Mercier[10] is used to estimate average annual lake phosphorus concentrations. This procedure accounts for the phosphorus retention capacity (assimilative capacity) of the lake as well as for total phosphorus concentrations of the inflow. The relationship between lake phosphorus concentration and inflow phosphorus concentration is expressed as follows.[10]

$$P_l = P_i\ (1 - R_p) \qquad (2\text{-}1)$$

where

P_l = Average annual lake phosphorus concentration in mg/l.

P_i = Average annual inflow phosphorus concentration in mg/l.

R_p = Phosphorus retention coefficient.

The phosphorus retention coefficient is a function of the average depth and retention time of the lake and is estimated by the following equation.[10]

$$R_p = \frac{10}{10 + Z/tw} \qquad (2\text{-}2)$$

where

Z = Mean depth of the lake in meters.

tw = Mean hydraulic retention time in years.

Since the watershed tributary to a lake is in general composed of both rural and urban lands, phosphorus removal requirements are proportioned to all sources. For example, if the average annual lake phosphorus concentration is determined to be 0.05 mg/l, an overall phosphorus removal of 50% would be required to meet the proposed criteria. This removal factor should be applied to all sources including combined sewer overflow and urban stormwater runoff as well as to wastewater treatment plant effluent and agricultural runoff. That is, the total required load reduction (in terms of pounds per year) should not be obtained only by control of combined sewer overflow and urban stormwater runoff.

RECREATION OBJECTIVE

The suitability of a receiving water for body contact recreation is largely a function of bacteriological contamination assuming that other quality factors are such that the fish and wildlife goal is met (i.e., DO, SS, toxic materials, and phosphorus).

The fecal coliform bacteria criteria recommended in "Quality Criteria for Water" for bathing waters are as follows.

> "Based on a minimum of five samples taken over a 30-day period, the fecal coliform bacterial level should not exceed a log mean of 200 per 100 ml, nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml."

The above criteria, in addition to all the receiving water criteria for the fish and wildlife goal, is used for evalution of facility needs for control of pollution from combined sewer overflow and urban stormwater runoff to achieve the recreation objective.

Considerable evidence exists which suggests that bacterial contamination from combined sewer overflow and urban runoff is massive. For example, fecal coliform concentrations in combined sewer overflow have been reported to range from $2.4(10)^5$ MPN/100 ml to $5(10)^6$ MPN/100 ml. Separate stormwater runoff contains fecal coliform bacteria in the range of $4(10)^4$ MPN/100 ml to $1.3(10)^6$ MPN/100 ml.[3] Thus, it may reasonably be concluded that any discharge of nondisinfected combined sewer overflow or urban stormwater runoff will result in exceedance of the criteria for fecal coliform bacteria.

Whether fecal coliform is the proper bacterial contamination indicator for combined sewer overflow and urban stormwater runoff is questionable, as discussed in references 11 and 12. However, nearly all existing water quality standards and criteria are based on allowable fecal coliform concentrations and disinfection is required to meet these existing criteria. Additional information related to health risks and benefits of both bacteriological contamination and disinfection should be obtained before substantial resources are committed, particularly in the case of urban stormwater runoff.

The only technically feasible alternative to achieve the recreation objective is to provide storage and treatment for nearly all stormflows. Thus, an allowable number of untreated overflow events in a given period of time must be established in order to determine facility needs to meet this objective.

Two untreated overflow events per year has been selected as the basis for estimating facility needs to meet the recreation receiving water quality objective.

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PART II

TECHNOLOGIES FOR COMBINED SEWER OVERFLOW AND URBAN STORMWATER RUNOFF CONTROL

Chapter 3
TECHNOLOGIES FOR THE CONTROL OF POLLUTION FROM COMBINED SEWER OVERFLOW AND URBAN STORMWATER RUNOFF

INTRODUCTION

Alternative technologies for the control of combined sewer overflow (CSO) and urban stormwater pollution must be adaptable to highly variable operating conditions and/or adaptable as dual wet- and dry-weather treatment facilities. They must also be flexible to site-specific conditions and subject to reliable automatic operation because rainfall produces an intermittent discharge of CSO and stormwater pollutants. In general, runoff-producing rainfall events occur during 200 to 1,300 hours per year, or from 2% to 15% of the time. Source control information, collection system control information, and treatment facility information presented in this chapter were taken from research reports published by the EPA Municipal Environmental Research Laboratory, Office of Research and Development, in the *Environmental Protection Technology Series*. Two EPA compendium reports are currently available which summarize the state-of-the-art in stormwater control technology.[1,2] The reader is referred to these reports for further information, including design and performance data which are not presented in this report.

SOURCE CONTROLS

Management practices to control the accumulation of pollutants on an urban watershed cannot be considered as independent pollution control alternatives. They are part of a total pollution control program and will play an important role in reduction of pollution from combined sewer overflow and urban stormwater runoff.

To control pollutants at their source, management practices must be applied where pollutants accumulate. For combined sewers, dry-weather deposition of sewage solids in the collection system is the major source of BOD_5, TN, PO_4, and coliform bacteria. Therefore, source control techniques which operate in the collection system, such as sewer flushing, can be expected to be more effective than source control techniques which operate on the land surface, such as street cleaning for BOD_5, nutrients, and coliform bacteria. On the other hand, lead is a pollutant which is associated with automobile use, and accumulation is predominantly on the street surface. Therefore, if removal of lead is of concern, street cleaning can be expected to be more effective than sewer flushing to achieve the given objective.

Source controls which operate on the land surface or which affect pollution accumulation, such as street cleaning, trash removal, and air pollution controls, will generally be more effective on separate watersheds than on combined sewer watersheds because the majority of the pollutants accumulate on the land surface rather than in the collection system.

Street Cleaning[3-8]

The major objective of municipal street cleaning is to enhance the aesthetic appearance of streets by periodically removing the surface accumulation of litter, debris, dust, and dirt. Common methods of street cleaning are manual, mechanical broom sweepers, vacuum sweepers, and street flushing. However, as currently practiced, street flushing does not remove pollutants from stormwater, but merely transports them from the street into the sewers.

Streetsweeping has received a great deal of attention during the last few years as a potential water quality control management practice. It has the major advantage of being applicable to highly developed, established urban areas. It also controls pollutants at the source and will improve general urban aesthetics as well as water quality. However, streetsweeping is only applicable to streets with curbs and gutters and often requires parking restrictions in order to be an effective pollution control alternative.

Streetsweeping effectiveness will depend upon the sediment transport and deposition characteristics of an urban watershed. However, in general, an effective streetsweeping program is a function of sweeper efficiency, frequency of cleaning, number of passes, equipment speed, pavement conditions, equipment type, fraction of streets swept, litter control programs, and street parking regulations.

Combined Sewer Flushing[9-12]

The major objective of combined sewer flushing is to resuspend deposited sewage solids and transmit these solids to the dry-weather treatment facility before a storm event flushes them to a receiving water. Combined sewer flushing consists of introducing a controlled volume of water over a short duration at key points in the collection system. This can be done using external water from a tanker truck with a gravity or pressurized feed or using internal water detained manually or automatically. Implementation requires a complete knowledge of how the existing collection system is operating.

Combined sewer flushing is most effective when applied to the flat portion of the collection system. Procedures are available to estimate the quantity and distribution of dry-weather deposition in sewers and for locating the optimum sites for sewer flushing. A recent feasibility study of combined sewer flushing indicates that manual flushing using an external pressurized source of water is most effective. No significant gain in the fraction of load removed was achieved by repeated flushing, and 70% of the flushed solids will quickly resettle. Therefore, repeated flushing in a downstream sequence is probably necessary to achieve significant pollutant reductions. Process efficiency is dependent upon flush volumes, flush discharge rate, sewer slope, length, diameter, wastewater flow rate, and efficiency of the wastewater treatment device receiving the resuspended solids.

Catch Basin Cleaning[13]

The major objective of catch basin cleaning is to reduce the first flush of deposited solids in a sewer system by frequently removing accumulated catch basin deposits. Methods to clean catch basins are manual, eductor, bucket, and vacuum. Less than 45% of the municipalities in the United States use mechanical methods.

The role of catch basins in newly constructed sewers is marginal due to improvements in street surfacing and design methods for providing self-cleaning velocities in sewers. Catch basins should be used only where there is a solids-transporting deficiency in the downstream sewers or at a specific site where surface solids are unusually abundant; however, many existing combined sewers have catch basins. A national survey of catch basin cleaning indicates that it is not a cost-effective alternative for stormwater pollution control. This is due in part to the limited amount of watershed pollutants found in catch basins and in part to the high cost of their removal.

COLLECTION SYSTEM CONTROL

Existing System Management[14]

The major objective of collection system management is to implement a continual remedial repair and maintenance program to provide maximum transmission of flows for treatment and disposal while minimizing overflow, bypass, and local flooding. It requires patience and an understanding of how the collection system works to locate unknown malfunctions of all types, poorly optimized regulators, unused in-line storage, and pipes clogged with sediments in old combined sewer systems.

The first phase of analysis in a sewer system study is an extensive inventory of data and mapping of flowline profiles. This information is then used to conduct a detailed physical survey of regulator and storm drain performance.

This type of sewer system inventory and study should be the first objective of any combined sewer overflow pollution abatement project.

Flow Reduction Techniques[15-20]

The major objective of flow reduction techniques is to maximize the effective collection system and treatment capacities by reducing extraneous sources of clean water. Infiltration is the volume of ground water entering sewers through defective joints; broken, cracked, or eroded pipe; improper connections; and manhole walls. Inflow is the volume of any kind of water discharged into sewerlines from such sources as roof leaders, cellar and yard drains, foundation drains, roadway inlets, commercial and industrial discharges, and depressed manhole covers. Combined sewers are by definition intended to carry both sanitary wastewater and inflow. Therefore, flow reduction opportunities are limited. Typical methods for reducing sewer inflow are by discharging of roof and areaway drainage onto pervious land, use of pervious drainage swales and surface storage, raising of depressed manholes, detention storage on streets and rooftops, and replacing vented manhole covers with unvented covers. Flow reduction requires a thorough analysis of the existing sewer system to maximize the effective capacities of collection systems and treatment works.

Sewer Separation[21-23]

Sewer separation is the conversion of a combined sewer system into separate sanitary and storm sewer systems. Separation of municipal wastewater from stormwater can be accomplished by adding a new sanitary sewer and using the old combined sewer as a storm sewer, by adding a new storm sewer and using the old combined sewer as a sanitary sewer, or by adding a "sewer within a sewer" pressure system. If combined sewers are separated, it must be remembered that storm sewer discharges may contribute a significant pollutant load relative to secondary wastewater treatment plant effluent and, therefore, may require some type of control even after the sewer systems are separated. For a small watershed sewer separation may be a cost-effective control alternative.

Inline Storage[12,24-29]

The major objective of inline sewer storage is to effectively control the ambient sewer volume so that a minimum amount of untreated overflow occurs. A prerequisite for this alternative is a large collection system with the potential for regulation of flow. Flow regulators may be static, manually operated dynamic, or computer-operated dynamic. Remotely controlled dynamic regulators are supported by telemetered real time information on rainfall, flow rates, and storage levels throughout the system.

Usable ambient inline storage is generally not sufficient to completely eliminate the overflow of untreated wastewater. It must, therefore, be combined with offline storage if high levels of pollutant capture are required. Compared to offline storage which may be considered, a 100% effective storage device static control of inline storage is approximately 60% effective, manual operation of dynamic controls is approximately 80% effective, and computer operation of dynamic controls is approximately 90% effective. That is if a given offline storage device (located at the treatment plant) of a certain capacity is capable of capturing 100,000 pounds of pollutants per year, that same total capacity available as static inline storage would capture on the order of 60,000 pounds of pollutants per year. Dynamic operation of this available inline storage could increase the annual capture to 80,000 or 90,000 pounds per year. The analysis of available data on the operation of inline storage indicates that dynamic real time controls perform better than static controls when rainfall is of a short duration, a high intensity, and is spatially variable. Remote real time control with an experienced operator is probably almost as effective as computer control, except for complex systems with many control options.

TREATMENT FACILITIES

Offline Storage[29-32]

The major objective of offline storage is to contain intermittent large volumes of stormwater for controlled releases into treatment facilities. Offline storage provides a more uniform constant flow and, thus, reduces the required size of treatment facilities. Offline storage facilities may be located at overflow points or near dry-weather or wet-weather treatment facilities. A major factor determining the feasibility of using offline storage is land availability. Operation and maintenance costs are generally small, requiring only collection and disposal costs for sludge solids unless input or output pumping is required. Many demonstration projects have included storage of peak stormwater flows.

Three types of offline storage basins can be constructed to meet site-specific problems and resources: earthen basins, uncovered concrete basins, and covered concrete basins.

Sedimentation

The major objective of sedimentation is to produce a clarified effluent by gravitational settling of the suspended particles that are heavier than water. It is one of the most common and well-established unit operations for wastewater treatment. Sedimentation also provides storage capacity, and disinfection can be effected concurrently in the same tank. It is also very adaptable to chemical additives such as lime, alum, ferric chloride, and polymers, which provide higher suspended solids, BOD, nutrients, and heavy metals removal.

Advantages of sedimentation are its familiarity to design engineers and operators and its minimal energy requirements. Disadvantages of sedimentation are its land requirement and its sensitivity to the duration of peak flow.

Dissolved Air Flotation[38-41]

The major objective of dissolved air flotation (DAF) is to achieve suspended solids removal in a shorter time than with conventional sedimentation, by attaching air bubbles to the suspended particles. The principal advantage of flotation over sedimentation is that very small or light particles that settle slowly can be removed more completely and in a shorter time. Capital costs for DAF are moderate; however, operating costs are relatively high due to the energy required to compress air and release it into the flotation basin and due to the greater skill required of operators. Chemical additives are also useful to improve process efficiencies of BOD and SS removals and to obtain nitrogen and phosphorus removals.

Advantages of DAF are its smaller land requirements and sludge volumes than with conventional sedimentation. Disadvantages of DAF are its higher costs and energy requirements than with conventional sedimentation.

Screens[41-44]

The major objective of screening is to provide high-rate pretreatment of stormwater by removing coarse materials. Three screening devices have been developed for this purpose, static screens, drum screens, and rotary screens.

For all screens, removal performance tends to improve as influent suspended solids concentrations increase, due to the relatively constant effluent concentrations. In addition, screens develop a mat of trapped particles which act as a strainer, retaining particles smaller than the screen aperture. Chemical additives can be used to improve process removal efficiencies. The use of screens in series does not show any advantage over the use of a single screen.

Advantages of screening are its relatively constant performance under highly variable flows, small land requirements, and adaptability to automatic operation. The major disadvantage of screening is that only particulate matter can be removed.

Microscreens[45]

The microscreen is a very fine screening device designed to be the main treatment process of a complete system. It has the potential to obtain very high suspended solids removal and 40% to 50% BOD_5 removal. Microscreen effluent is also more easily disinfected due to solids breakup.

High-Rate Filtration[46-50]

The major objective of high-rate filtration (HRF) is to capture suspended solids and other pollutants on a fixed bed dual media filter (a bed of anthracite coal is usually above sand filter media). Filtration is one step more efficient than screening. Solids are usually removed by one or more of the following mechanisms: straining, impingement, settling, and adsorption. Filtration has not been widely used in wastewater treatment because of rapid clogging caused by compressible solids. CSO and stormwater contain a larger fraction of discrete, noncompressible solids, which can easily be cleaned from the filter media by periodic backwashing. HRF has been developed over the past 15 years for a variety of treatment applications, mainly industrial wastewater treatment. Advantages of HRF are its smaller land requirements and its suitability to automatic operation. The major disadvantage of HRF is its moderately high energy use.

Swirl and Helical Concentrators[51-54]

The major objective of swirl and helical concentrators is to regulate both the quantity and quality of stormwater at the point of overflow. Solids separation is caused by the inertia differential which results from a circular path of travel. The flow is separated into a large volume of clear overflow and a concentrated low volume of waste that is intercepted for treatment at the wastewater treatment plant. In addition to regulation of combined sewer flow, they can provide high-rate primary treatment for solids removal. Swirl and helical bend concentrators have been modeled and, in several cases, demonstrated for various processes, including treatment and flow regulation, primary treatment, and erosion control. A major attribute of the swirl concentrator is the relatively constant treatment efficiency over a wide range of flow rates (a five-fold flow increase results in only about a 25% efficiency reduction) and the absence of mechanical parts which use energy, unless input or output pumping is required.

Disadvantages of the swirl concentrator are its limited full-scale operating experience and its inability to remove dissolved pollutants.

Chemical Additives[55]

The major objective of using chemical additives is to provide a higher level of treatment than is possible with unaided physical treatment processes (sedimentation, dissolved air flotation, and high-rate filtration). Chemicals commonly used are lime, aluminum or iron salts, polyelectrolytes, and combinations of these chemicals. There is no rational method for predicting the chemical dose required. Jar tests are used for design purposes; however, field control is essential since the chemical composition of CSO and stormwater is highly variable. The major advantage of using chemical additives with physical treatment is the increased pollutant removals, including removal of dissolved pollutants. The major disadvantages of using chemical additives are the higher energy and treatment costs, greater sludge volumes, and the necessity of experienced personnel to monitor the application of chemicals.

Coagulation and Flocculation[55]

The major objective of coagulation and flocculation is to permit aggregation of colloidal particles prior to sedimentation. Coagulation is the term which describes the overall process of particle aggregation, including both particle transport to cause interparticle contact and particle destabilization to permit the attachment of particles once contact has occurred. Flocculation is the term used to describe the transport step only. Coagulation requires the addition of chemical additives as described above.

Disinfection[45,56-59]

The major objective of disinfection is to control pathogens and other microorganisms in receiving waters. The disinfection agents commonly used in CSO and stormwater treatment are chlorine, calcium or sodium hypochlorite, chlorine dioxide, and ozone. They are all oxidizing agents, are corrosive to equipment, and are highly toxic to both microorganisms and people. Physical methods and other chemical agents have not had wide usage because of excessive costs or operational problems. The choice of a disinfecting agent will depend upon the unique characteristics of each agent, such as stability, chemical reactions with phenols and ammonia, disinfecting residual, and health hazards. Adequate mixing must be provided to force disinfectant contact with the maximum number of microorganisms. Mixing can be accomplished by mechanical flash mixers at the point of disinfectant addition, at intermittent points by specially designed contact chambers, or both. Chlorine may enhance aftergrowth of microorganisms in the receiving water by cleaving large protein molecules into small proteins, peptides, and other amino acids.

Sludge Disposal[60]

As with all treatment processes, the concentrated waste residue generated by CSO and stormwater treatment must be disposed of properly. It is estimated that treatment of CSO will generate 41.5 billion gallons of sludge per year, which is approximately 2.6 times the volume of raw primary wastewater treatment plant sludge. However, the average solids concentration in CSO sludge is about 1%, compared to 2% to 7% in raw primary sludge. This is due to the high volume, low solids residuals generated by treatment processes employing screens. CSO residuals have a high grit and low volatile solids content when compared to raw primary sludge. The same is true for urban stormwater. Regarding the effect of toxic materials in combined sewage sludges affecting its suitability for application on agricultural lands, an EPA report entitled "Municipal Sludge Management: Environmental Factors," EPA 430/9-77-004, October 1977, presents total amount in pounds per acre of sludge metals allowed on agricultural land for lead, zinc, copper, nickel, and cadmium. These amounts should not be exceeded for sludges from separate sanitary wastewater combined sewer overflow or urban stormwater runoff.

Preliminary economic evaluation indicated that lime stabilization, storage, gravity thickening, and land application comprise the most cost-effective disposal system. Costs for overall CSO sludge handling depend on the type of CSO treatment process, volume and characteristics of the sludge, and the size of the CSO area, among other considerations. Estimates indicate that first investment capital costs range from $181 to $4,129 per acre and annual operating costs range from $56 to $660 per acre. The above-mentioned report recommends that the use of grit removal, lime stabilization, and gravity thickening plus dewatering be further investigated to establish specific design criteria for CSO sludge disposal.

Biological Treatment[33,61-64]

The major objective of biological treatment is to remove the nonsettleable colloidal and dissolved organic matter by biologically converting them into cell tissue which can be removed by gravity settling. Several biological processes have been applied to combined sewer overflow treatment, including contact stabilization, trickling filters, rotating biological contactors, and treatment lagoons. Biological treatment processes are generally categorized as secondary treatment processes. These processes are capable of removing between 70% and 95% of the BOD_5 and suspended solids from waste flows at dry-weather flow rates and loadings. A operational problem when treating intermittent wet-weather storm events by biological processes is maintaining a viable biomass. Biological systems are extremely susceptible to overloaded conditions and shock loads when compared to physical treatment processes, with the possible exception of rotating biological contactors. This and the high initial capital costs are serious drawbacks for using biological systems to treat intermittent CSO and stormwater, unless they are designed as a dual treatment facility. Therefore, biological treatment of CSO and stormwater is generally viable only in integrated wet/dry-weather treatment facilities. Since the application of a dual biological treatment facility is extremely site-specific, cost data for biological treatment systems are not considered in Chapter 4 and the needs estimate is based on single purpose physical/chemical treatment of CSO and urban stormwater runoff.

High Gradient Magnetic Separation[65-69]

The major objective of high gradient magnetic separation (HGMS) is to bind suspended solids to small quantities of a magnetic seed material (iron oxide called magnetite) by chemical coagulation and then pass them through a high gradient magnetic field for removal. Magnetic separation techniques have been used since the 19th century to remove tramp iron and to concentrate iron ores. Solids are trapped in a magnetic matrix which must be cyclically back-flushed like screens and filters.

Application of HGMS to treat CSO and stormwater is still in the research stage and no full-scale facilities have been constructed; however, it may prove to be competitive with other alternative technology. The major attributes of HGMS are the 90%+ BOD_5 removal with a detention time of 3 minutes, the ability to remove nutrients and heavy metals, small land requirements, reduced chlorine demand for disinfection, and capital and operation and maintenance are estimated to be lower than comparative physicochemical treatment. The major disadvantage of HGMS is that no full-scale facilities have been constructed. Therefore prototype performance and cost data are not available.

Carbon Adsorption[55,70,71]

The major objective of carbon adsorption is to remove soluble organics as part of a complete physicochemical treatment system which usually includes preliminary treatment, sedimentation with chemicals, filtration, and disinfection. Carbon contacting can be done using either granular activated carbon in a fixed or fluidized bed or powdered activated carbon in a sedimentation basin. Periodic backwashing of the fixed bed must be provided, even if prefiltration is used, because suspended solids will accumulate in the bed. A physicochemical treatment system utilizing powdered activated carbon, coagulated with alum, settled with polyelectrolyte addition, and in some cases, passed through a trimedia filter was demonstrated in Albany, New York, during 1971 and 1972 to treat combined sewer overflow. Application of carbon adsorption is well suited to advanced waste treatment of sanitary sewage. However, the feasibility of application to CSO and urban stormwater is dependent upon the effluent quality objectives, the degree of preunit flow attenuation, and the ability to obtain dual dry- and wet-weather use of treatment facilities.

The major attributes of carbon adsorption are the 90%+ BOD_5 removal, the ability to remove refractory organic material, and small land requirements.

The major disadvantage of carbon adsorption is the limited full-scale experience of treating CSO and urban stormwater. As a result, reliable cost data are not available.

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Chapter 4
COST FUNCTIONS FOR CONTROL OF POLLUTION FROM COMBINED SEWER OVERFLOW AND URBAN STORMWATER RUNOFF

INTRODUCTION

The purpose of this chapter is to present equations for capital and operation and maintenance (O&M) costs for various alternatives which may be used to control pollution from urban stormwater runoff and combined sewer overflow. Cost equations and unit cost data are derived from the references cited.

A literature review was completed in order to identify sources of information on capital and O&M costs for control alternatives ranging from collection system controls to storage/treatment systems. Since most cost data reported in the literature were referenced to the ENR construction cost index, this index was used as the basis for updating historic data to present (January 1978) costs. The ENR construction cost index for January 1978 is 2,672, and all cost data presented here are for this base.

Where sufficient cost and capacity data were available, regression analysis was used to define the relationship of best fit. Both linear and logarithmic cost estimating models were considered.

SEWER SEPARATION

Unit sewer separation construction costs, expressed as dollars per acre of sewers separated, were obtained from various sources in the literature and are summarized in Table 4-1. Also listed in Table 4-1 is the population density, expressed in persons per acre, of the combined sewer service area. Simple linear regression of the population density values versus the cost values yields the following equation.

$$Css = 1{,}779 \times PD \qquad (4\text{-}1)$$

where

Css = Capital cost of sewer separation in dollars per acre.

PD = Population density of the combined sewer service area in persons per acre.

Figure 4-1 illustrates the data points and the resultant equation. Two data pairs, Boston and San Francisco, were considered outliers and were not used in the final regression analysis.

Table 4-1
Sewer Separation Capital Costs Summary

Cost ($/acre)	ENR Index	Cost ($/acre) ENR = 2672	Population Density (persons/acre)	City	Reference
17,846	2305	20,687	6.9	Norwich	1
22,824	2410	25,306	--	Norwalk	2
32,279	2700	31,944	19.9	Milwaukee	3
81,800	2000	109,285	26.4	Boston	4
4,930	2000	6,586	5.5	Bucyrus	4
4,660	2000	6,226	5.5	Bucyrus	4
28,220	2000	37,702	27.5	Chicago	4
8,420	2000	11,249	--	Chippewa Falls	4
32,300	2000	43,153	11.7	Cleveland	4
6,450	2000	8,617	8.3	Des Moines	4
20,680	2000	27,628	16.5	Sandusky	4
41,210	2000	55,057	67.5	San Francisco	4
9,830	2000	13,132	11.7	Seattle	4
66,250	2000	88,510	45.0	Washington, D.C.	4
52,950	2000	70,741	45.0	Washington, D.C.	4

Note: The estimated unit cost and population density for Milwaukee was obtained from a recent reference (February 1979). An earlier estimate of unit cost and population density was used in the regression analysis.

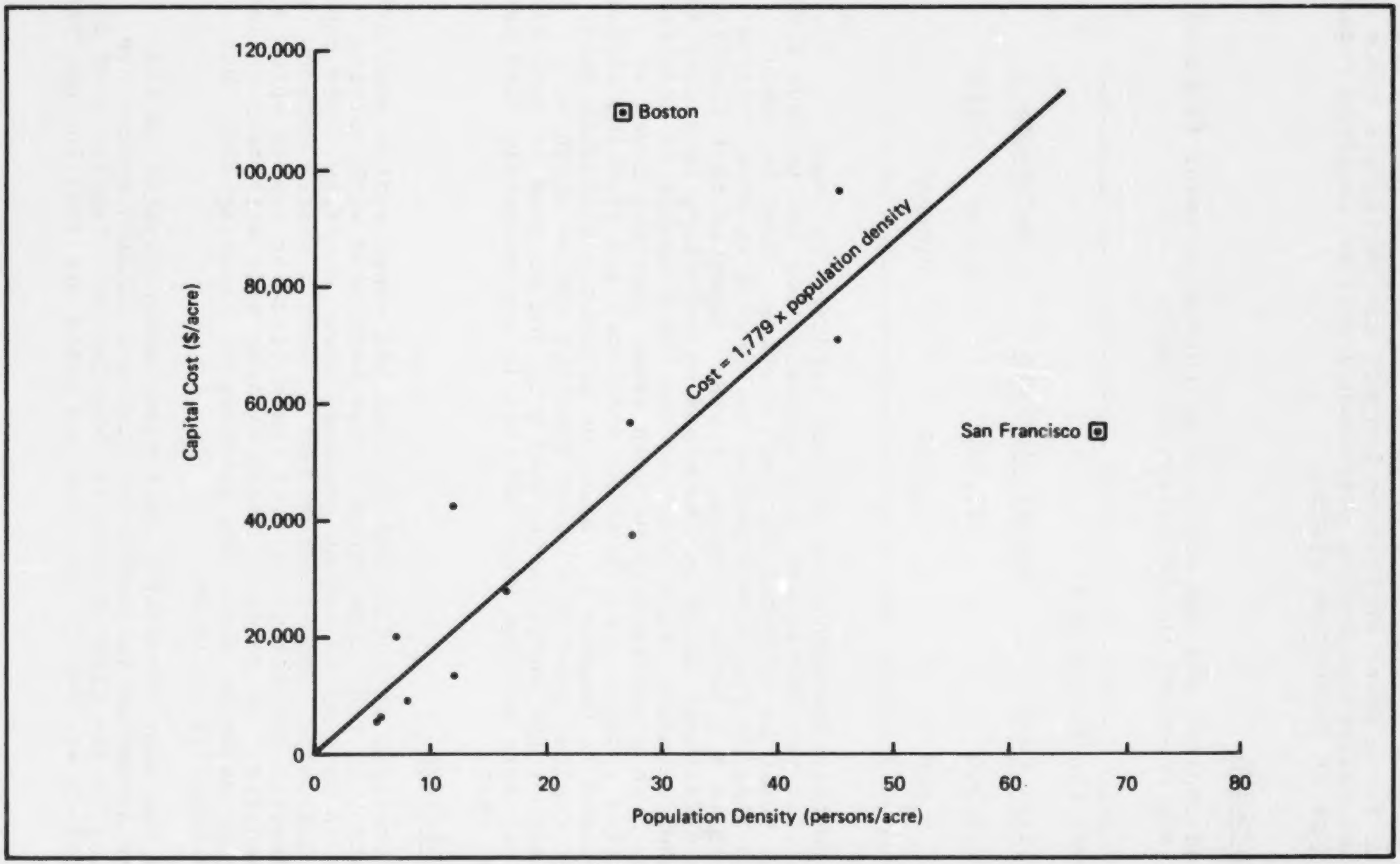

FIGURE 4-1. Capital cost of sewer separation.

For the purpose of the needs estimate, it will be assumed that O&M costs for a sewer separation project are negligible since wastewater collection system maintenance will be required regardless of the type of collection system.

SEWER FLUSHING

Installed capital and O&M costs of an automatic sewer flushing station are reported in the following table.

Sewer Flushing Costs

Capital Cost	Annual O&M Cost	Reference
$4,260	$1,880	Lager & Smith[4]
9,000	1,630	Pisano[9]

In the Detroit demonstration project reported by Lager & Smith[4], it was determined that approximately two to four flushing stations would be required for each 9 acres. That is, each flushing station could be expected to service an area ranging from 2.25 to 4.5 acres in size. Pisano[9] reported that flushing station efficiency could be increased by selecting locations in flat sewer segments, thus reducing the total number of required stations. The relationship between sewer flushing level of effort (i.e., density of flushing stations) and flushing efficiency is discussed in Chapter 6. Based on presently available data, the unit capital cost of a sewer flushing system which will remove 40% of the annual watershed BOD_5 and SS load is approximately $1,000 per acre and the unit O&M cost is approximately $180 per acre per year.

Inline Storage

Inline storage, including remote combined sewer system monitoring and control or real time control, has been used with varying degrees of success to reduce combined sewer overflow. The capital costs, O&M costs, and effectiveness of such a system depends upon the hydraulic characteristics of the collection system which are site specific. In general, these systems will work best on large collection networks where the interceptor capacity and, thus, storage capacity is large.

Perhaps the most successful real time control system is the Computer Augmented Treatment and Disposal (CATAD) system now operating in the City of Seattle, Washington. Capital cost of this project was $4,141,000, and O&M costs are $267,200 per year.

However, insufficient cost and performance data are available from other inline storage and remote monitoring and control systems to generalize unit costs or removal efficiencies.

Offline Storage

The most complete source of information on the cost of stormwater storage is the "Cost Estimating Manual--Combined Sewer Overflow Storage and Treatment."[7] Capital costs for three types of offline storage are presented. These are (1) earthen basins, (2) concrete basins uncovered, and (3) concrete basins covered. The capital cost equations are as follows.

1. Earthen basins

$$Cs = 30{,}300\ V^{0.783} \tag{4-2}$$

2. Concrete basins uncovered

$$Cs = 465{,}000\ V^{0.619} \tag{4-3}$$

3. Concrete basins covered

$$Cs = 528{,}000\ V^{0.790} \tag{4-4}$$

where

Cs = Capital cost of storage basin in January 1978 dollars.

V = Volume of basin in million gallons.

Annual operation and maintenance costs are separated into three categories: labor, supplies, and power. The labor cost equation is based on 30 operation cycles per year (i.e., runoff events) and on a unit labor cost of $12.12 per man-hour. The labor cost equation is given as follows.

$$CLs = 2{,}670\ V^{0.509} \tag{4-5}$$

where

CLs = Annual cost of labor for maintenance of storage facilities in January 1978 dollars.

The annual cost of supplies is given by the following equation.

$$CSs = 618\ V^{0.405} \tag{4-6}$$

where

CSs = Annual cost of supplies for storage facilities in January 1978 dollars.

The power cost equation given below is based on 80 days of operation per year and on a unit power cost of 2.42 cents per kilowatt hour (kWh).

$$CPs = 15.8\ V^{0.493} \qquad (4-7)$$

where

CPs = Annual cost of power for storage facilities in January 1978 dollars.

PHYSICAL/CHEMICAL TREATMENT

Cost equations were derived from the cost estimating manual[7] and compared to the cost equations used in the 1976 Needs Survey[6] for the following items or physical/chemical processes.

Administration.
Yardwork.
Laboratory.
Sedimentation.
Dissolved air flotation.
Screens.
Microstrainer.
Filtration.
Swirl concentrators.
Pumping (wastewater).
Pumping (sludge).
Sludge disposal.
Flow measurement.
Chemical mixing.
Rapid mixing.
Flocculation.
Disinfection.

Where available, cost equations derived from data presented in "Cost Estimating Manual--Combined Sewer Overflow Storage and Treatment"[7] are used. If equations cannot be derived from this source, then equations derived from other sources, including equations updated from the 1976 Needs Survey are utilized. Cost equations used in this project are presented in Table 4-2. All O&M cost equations are based on 30 operation cycles per year and a total time of operation of 80 days per year.

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Table 4-2
Capital and Operation and Maintenance Cost Functions for Physical/Chemical Treatment of CSO and Urban Stormwater Runoff

Treatment Process	Design Parameter	Capital Costs (dollars)	Annual Costs (dollars/yr) Labor	Annual Costs (dollars/yr) Supplies	Annual Costs (dollars/yr) Power	Reference
Administration	--	--	$232Q^{.463}$	$87Q^{.471}$	--	6
Laboratory	400 samples per year	--	9,970	2,550	--	6
Yardwork	--	--	$1{,}010Q^{.798}$	$66Q^{.838}$	--	6
Sedimentation	1,500 gpd/ft^2	$52{,}000\ Q^{.817}$	$3{,}870Q^{.702}$	$1{,}520Q^{.212}$	$4.15\ Q^{.779}$	7
Dissolved air flotation	3,600 gpd/ft^2	$163{,}000\ Q^{.658}$	$3{,}260Q^{.618}$	$4{,}770Q^{.870}$	$1{,}180\ Q$	7
Screening	--	$16{,}700\ Q^{.972}$	$3{,}880Q^{.287}$	$848Q^{.273}$	--	7
Microstrainer	--	$35{,}000\ Q^{.846}$	$3{,}880Q^{.287}$	$848Q^{.273}$	--	5,7
Filtration	10 gpm/ft^2	$127{,}000\ Q^{.735}$	$27{,}600 + 29\ Q$	$1{,}020Q^{.237}$	$16.7\ Q$	7
Swirl concentrator	--	$13{,}000\ Q^{.818}$	$2{,}980Q^{.316}$	--	--	7
Raw wastewater pumping	--	$113{,}000\ Q^{.833}$	$4{,}790Q^{.188}$	$69Q$	$140\ Q$	6,7
Sludge pumping	--	$288{,}000\ Q_s^{.502}$	$9{,}600\ Q_s^{.413}$	$1{,}100Q_s^{.643}$	$145\ Q_s$	7

Table 4-2--Continued

Treatment Process	Design Parameter	Capital Costs (dollars)	Annual Costs (dollars/yr)			Reference
			Labor	Supplies	Power	
Sludge disposal	--	$58,100\ Q^{.608}$	$9,950\ Q$	--	--	6
Flow measurement	--	$3,800\ Q^{.484}$	--	--	--	7
Chemical mixing	Up to 75 mg/l	$55,600\ Q^{.611}$	$4,020Q^{.332}$	$41.7Q^{.662}$	$23Q^{.86}$	6
Rapid mixing	Td = 2 min	$6,190\ Q^{.724}$	$98.5Q^{.884}$	$30Q^{.698}$	$63Q$	6
Flocculation	Td = 30 min	$30,000\ Q^{.612}$	$392Q$	$206Q^{.641}$	$63Q$	6,7
Disinfection	Up to 7 mg/l dosage	$73,100 + 6,020Q$	$2,060Q^{.597}$	$1,320Q^{.690}$	--	6

Note: All costs are in January 1978 dollars (ENR = 2,672).
Q = Design flow rate in mgd.
Q_s = Sludge pumping rate in mgd ($Q_s = 0.05Q$--$0.10Q$).
Td = Detention time.

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Chapter 5
TREATMENT ALTERNATIVES AND REMOVAL EFFICIENCIES

INTRODUCTION

The purpose of this chapter is to present pollutant removal efficiencies for individual physical/chemical treatment processes and to combine these processes into treatment trains that offer cost-effective pollutant removal. Cost functions presented in Chapter 4 are used to derive equations for estimating the capital and annual costs of each treatment train.

RANKING INDIVIDUAL TREATMENT PROCESSES

Removal efficiencies of individual physical/chemical treatment processes are often erratic and unpredictable and depend on loading rates or other process variables. An extensive literature search of physical/chemical process removal efficiencies, including a compendium on the state-of-the-art in urban storm water management and technology[1], is summarized in Table 5-1. The removal efficiencies reported in Table 5-1 are believed to be typical for the processes, loading rates, and pollutants considered. Individual efficiencies may vary considerably from the values reported, depending on the characteristics of the runoff.

The seven treatment processes considered are storage, sedimentation, dissolved air flotation with prescreening, dissolved air flotation with prescreening and chemical addition, flocculation-sedimentation, high-rate filtration, and microscreening. Storage is assumed to have a detention time of 12 hours or greater and, therefore, is assumed to achieve removals that are equivalent to plain sedimentation.

Using the cost equations presented in Chapter 4 and the removal efficiencies in Table 5-1, it was possible to estimate a typical unit capital cost expressed in dollars per mgd treated per percent pollutant removed for each of the seven treatment processes. The results of the unit capital cost calculations are presented in Table 5-2. Storage is not applicable to this calculation since it is included with any treatment train.

The data in Table 5-2 are also ranked in order of increasing unit capital costs. This ranking results in a priority rating for each process based on its pollutant removal cost effectiveness. The ranking ranges from one for microscreens to six for dissolved air flotation without chemical addition.

Table 5-1
Pollutant Removal Efficiencies of
Individual Physical/Chemical Treatment Processes

Treatment Process	Pollutant Removal (%)			
	BOD_5	SS	TKN	Pb
Storage	25	30	35	30
Plain sedimentation Loading Rate = 1,500 gal/ft^2-day	25	30	35	30
Dissolved air flotation (with prescreening) Loading Rate = 3,600 gal/ft^2-day	45	50	25	50
Dissolved air flotation (with prescreening and chemical addition) Loading rate = 3,600 gal/ft^2-day	60	70	25	70
Flocculation-Sedimentation (with lime)	60	75	25	75
High rate filtration Loading rate = 14,400 gal/ft^2-day	55	65	25	65
Microscreen (23-micron)	35	80	30	50

Table 5-2
Unit Capital Costs
and Ranking of Individual
Physical/Chemical Treatment Processes

Treatment Process	Unit Capital Costs ($/mgd-% removed)			
	BOD_5	SS	TKN	Pb
Storage	NA	NA	NA	NA
Plain sedimentation Loading Rate = 1,500 gal/ft^2-day	1,366 (4)	1,138 (4)	975 (4)	1,138 (4)
Dissolved air flotation (with prescreening) Loading rate = 3,600 gal/ft^2-day	1,645 (6)	1,481 (6)	2,962 (6)	1,481 (6)
Dissolved air flotation (with prescreening and chemical addition) Loading rate = 3,600 gal/ft^2-day	1,612 (5)	1,382 (5)	3,870 (5)	1,382 (5)
Flocculation-sedimentation (with lime)	774 (2)	619 (2)	1,857 (2)	619 (2)
High-rate filtration Loading rate = 14,400 gal/ft^2-day	1,251 (3)	1,059 (3)	2,754 (3)	1,059 (3)
Microscreen (23-micron)	701 (1)	306 (1)	818 (1)	491 (1)

Note: The number in parenthesis indicates the individual treatment process rank in order of increasing unit capital costs.

Selection of Treatment Trains

The ranking of unit capital costs for physical/chemical treatment processes provides a basis for adding individual treatment processes in series to obtain the maximum pollutant removal at the least cost. Unit capital cost data from Table 5-2 indicate that physical/chemical treatment processes should be added to storage in the following order; microscreening, sedimentation-flocculation, high-rate filtration, and then dissolved air flotation with prescreening and chemical addition. Plain sedimentation is not considered because sedimentation is included in the flocculation-sedimentation process. The result of this analysis is five levels of treatment, as shown schematically in Figures 5-1, 5-2, and 5-3.

When treatment processes are used in series, the total pollutant removed may be estimated using the following equation[2].

$$R_o = R_1 + R_2\,(100 - R_1) \qquad (5\text{-}1)$$

where

R_o = Total pollutant removed by two treatment processes in series, in percent

R_1 = Pollutant removed by treatment process 1, in percent, and

R_2 = Pollutant removed by treatment process 2, in percent.

Using equation 5-1, pollutant removal efficiencies are estimated for the five treatment levels and presented in Table 5-3. Since storage basins can provide a practical maximum of approximately 98% capture of all watershed pollutants, the maximum watershed pollutant removal is slightly less than the treatment level removal efficiency. Practical maximum watershed removal efficiencies are also reported in Table 5-3.

Using the cost equations presented in Chapter 4, the capital, operation and maintenance, and equivalent annual costs of each component of the five treatment trains were estimated and composite cost equations were developed and are reported in Table 5-4. These cost functions are based on treatment rates of 1 to 100 mgd and are used in the economic optimization portion of the needs estimate.

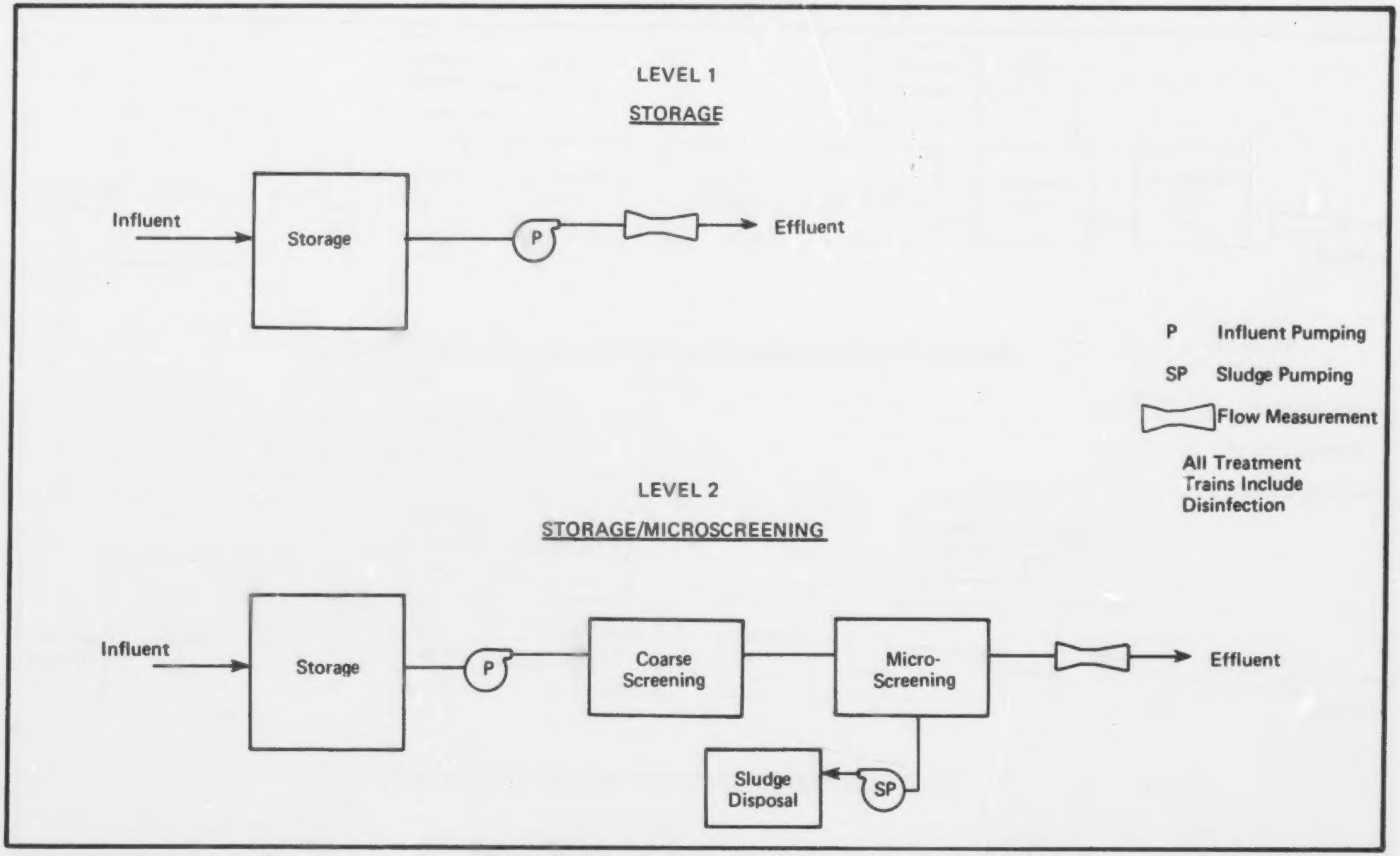

FIGURE 5-1. Process trains for treatment levels 1 and 2.

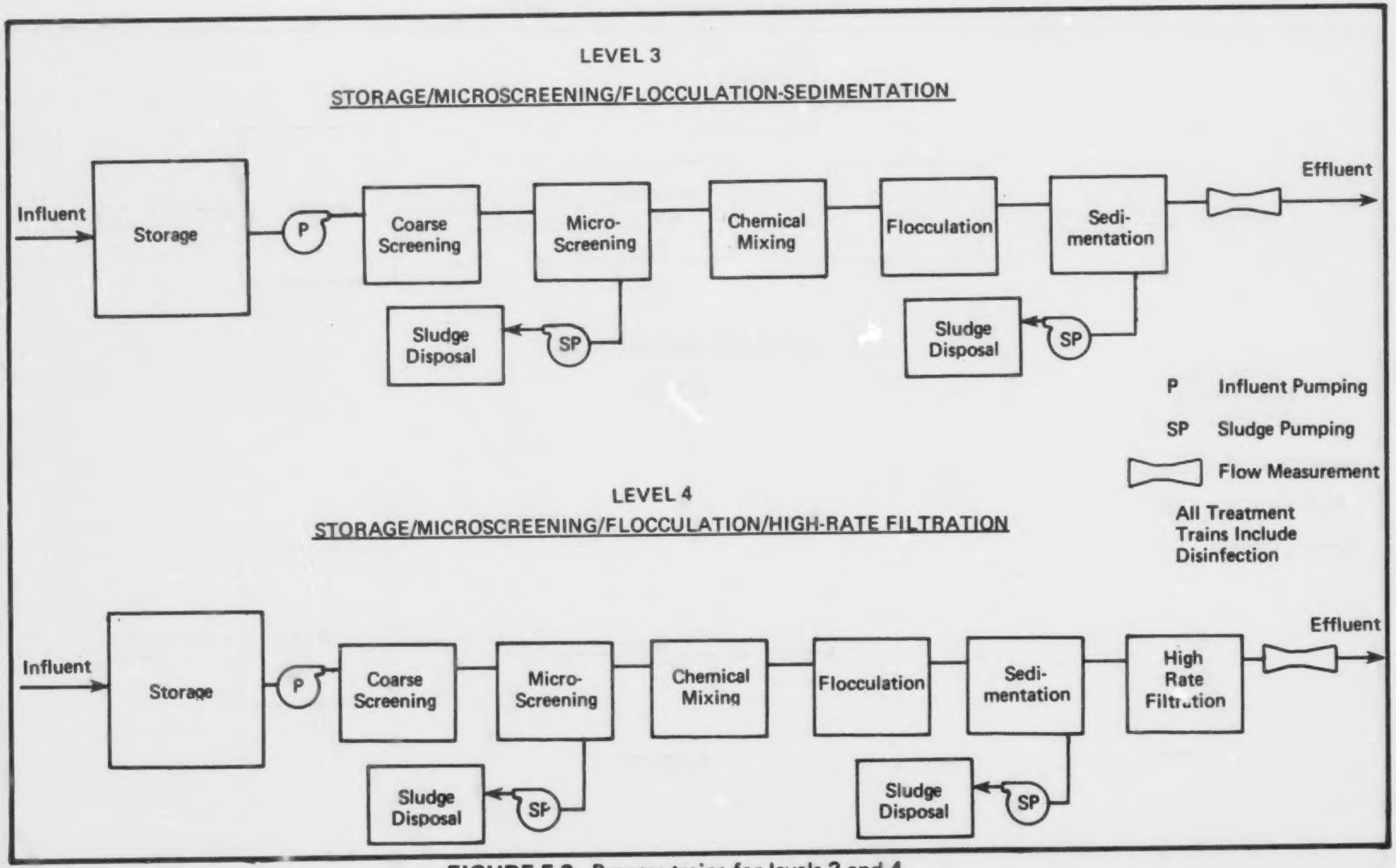

FIGURE 5-2. Process trains for levels 3 and 4.

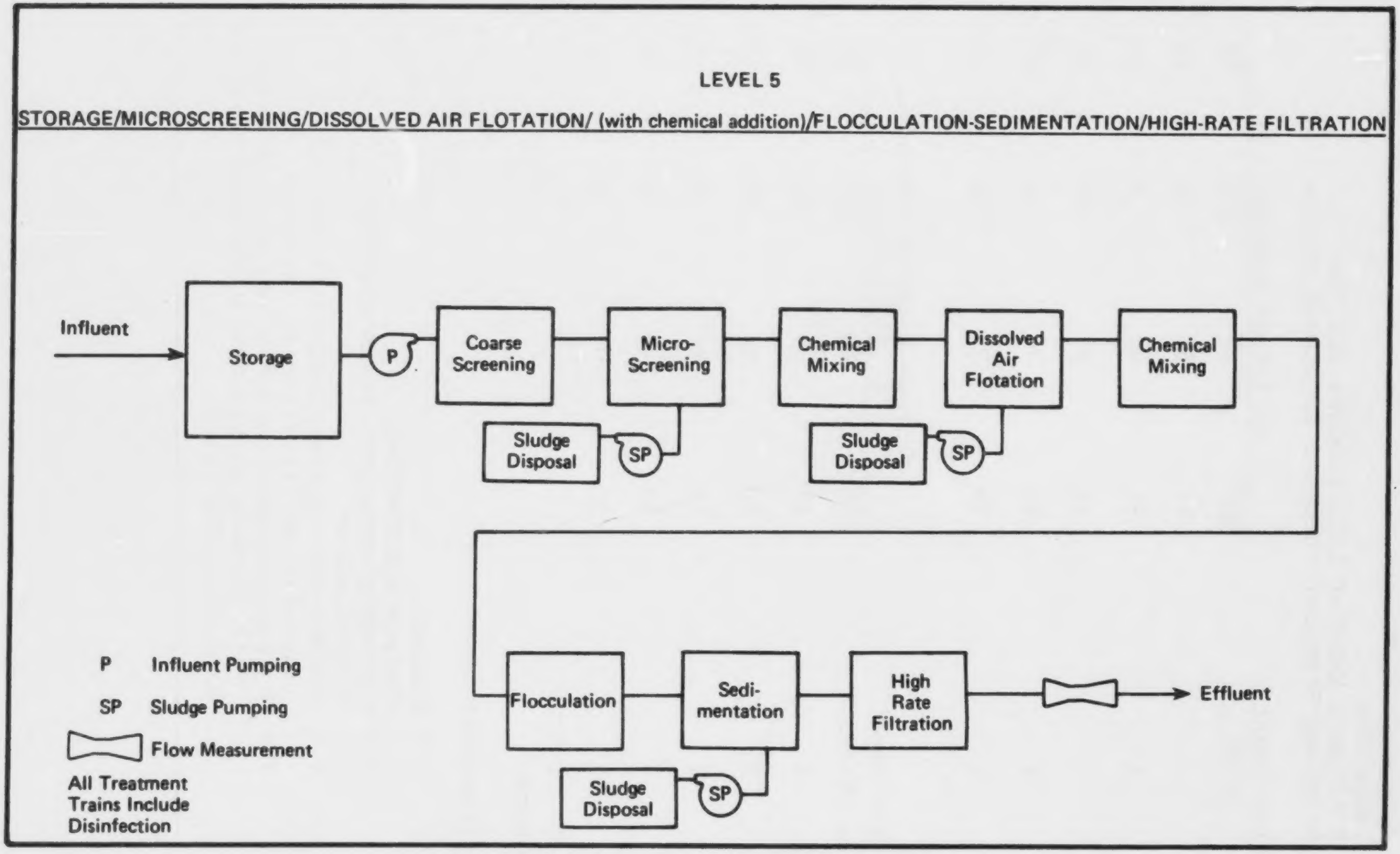

FIGURE 5-3. Process train for treatment level 5.

Table 5-3
Pollutant Removal Efficiencies for the Selected Physical/Chemical Treatment Trains

Treatment Level	Pollutant Removal (%)			
	BOD_5	SS	TKN	Pb
1	25	30	35	30
2	51	86	55	65
3	81	97	66	91
4	91	99	74	97
5	96	99	81	99

Treatment Level	Maximum Watershed Removal At 98% Capture			
	BOD_5	SS	TKN	Pb
1	25	29	34	29
2	50	84	54	64
3	79	95	65	89
4	89	97	73	95
5	95	97	79	97

Note:

Treatment Level

1 = Storage
2 = Storage/microscreen
3 = Storage/microscreen/sedimentation-flocculation
4 = Storage/microscreen/sedimentation-flocculation/high-rate filtration
5 = Storage/microscreen/dissolved air flotation (with chemicals)/sedimentation-flocculation/high-rate filtration

Table 5-4
Capital, Operation and Maintenance, and
Equivalent Annual Costs of Selected
Physical/Chemical Treatment Trains

Treatment Level	Capital Cost (dollars)	O&M Costs (dollars/year)	Equivalent Annual Costs (dollars/year)
1	182,500$Q^{.735}$	19,900$Q^{.406}$	35,900$Q^{.609}$
2	376,000$Q^{.716}$	43,500$Q^{.687}$	78,100$Q^{.700}$
3	631,000$Q^{.693}$	65,200$Q^{.753}$	122,800$Q^{.727}$
4	758,000$Q^{.700}$	87,700$Q^{.680}$	157,800$Q^{.688}$
5	1,096,000$Q^{.678}$	112,900$Q^{.734}$	213,000$Q^{.711}$

Notes:
1. All costs are in January 1978 dollars (ENR = 2,672).
2. Storage costs are not included.
3. Annual costs are based on an interest rate of 6-5/8%, a project life of 20 years, and include operation and maintenance costs.
4. Q = design flow rate in mgd.

Treatment Level

1 = Storage.
2 = Storage/microscreen.
3 = Storage/microscreen/sedimentation-flocculation.
4 = Storage/microscreen/sedimentation-flocculation/high-rate filtration.
5 = Storage/microscreen/dissolved air flotation (with chemicals)/sedimentation-flocculation/high-rate filtration.

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Chapter 6
PRODUCTION FUNCTIONS FOR COMBINED SEWER OVERFLOW AND URBAN STORMWATER RUNOFF POLLUTION CONTROL ALTERNATIVES

INTRODUCTION

The purpose of this chapter is to define production functions for the economic optimization of CSO and urban stormwater runoff pollution control alternatives, based on existing literature.

A production function may be defined as a relationship between level of effort and output. In the context of control of pollution from urban stormwater runoff and combined sewer overflow, the level of effort will take on different meanings for different control techniques. For example, in a streetsweeping program, level of effort may be measured in terms of the fraction of total streets swept daily, whereas, in a storage/treatment system, level of effort may be measured as the size of the storage treatment facility constructed to capture a desired percentage of the annual runoff. The output of these functions is always expressed in terms of the amount of pollutants removed from the watershed.

Knowledge of the production function for various wet-weather pollution control alternatives is required to obtain the least costly pollution control strategy which also meets the desired pollutant removal. In addition to the production function which relates the level of effort to pollution removal, the relationship between effort and cost must also be known. Cost data for the 1978 Needs Survey have been presented in Chapter 4. Production functions are considered for the following control alternatives.

1. Storage/treatment systems.
2. Streetsweeping.
3. Sewer flushing.
4. Combined sewer separation.
5. Real time control systems.

In each case except for real time control systems, a generalized production function has been identified and is discussed herein. The cost and performance of a real time combined sewer system control is a function of site-specific conditions. Insufficient data are available on which to base national estimates.

STORAGE/TREATMENT SYSTEMS

Application of production theory to the stormwater pollution control problem was first proposed by Heaney, et al.[1] The problem under consideration at that time was the optimization of a storage/treatment system which required the development of a production function for a system which produces one output (pollutant removal) as the result of two inputs (storage and treatment).

Figure 6-1 is a definition sketch of a production function for a two input/one output system. The production function takes the form of a family of curves which define combinations of storage and treatment which will achieve an equal level of annual pollutant removal. These curves are termed isoquants since they define combinations of the two inputs which result in an equal value of output. If lines of equal annual cost, termed isocost lines, are constructed and superimposed on the isoquants, then the point of minimum cost for each level of control can be identified. The curve which connects these minimum cost points is termed the expansion path and defines the optimum relationship between storage and treatment.

The key to determination of the expansion path is the construction of the storage treatment isoquants which are functions of the hydrologic characteristics of the site. Storage treatment isoquants have been defined by the following equation.[1]

$$T = T_1 + (T_2 - T_1)\, e^{-KS} \qquad (6\text{-}1)$$

where

T = Treatment rate in inches per hour.

T_1 = Treatment rate at which isoquants become parallel to the ordinate, in inches per hour.

T_2 = Treatment rate at which isoquant intersects the abscissa, in inches per hour.

S = Storage volume in inches.

K = Constant in inches^{-1}.

T_1 is defined as follows.

$$T_1 = \frac{AR}{8760} \cdot \frac{C}{100} \qquad (6\text{-}2)$$

where

AR = Annual runoff in inches per year.

C = Percent of pollutants captured.

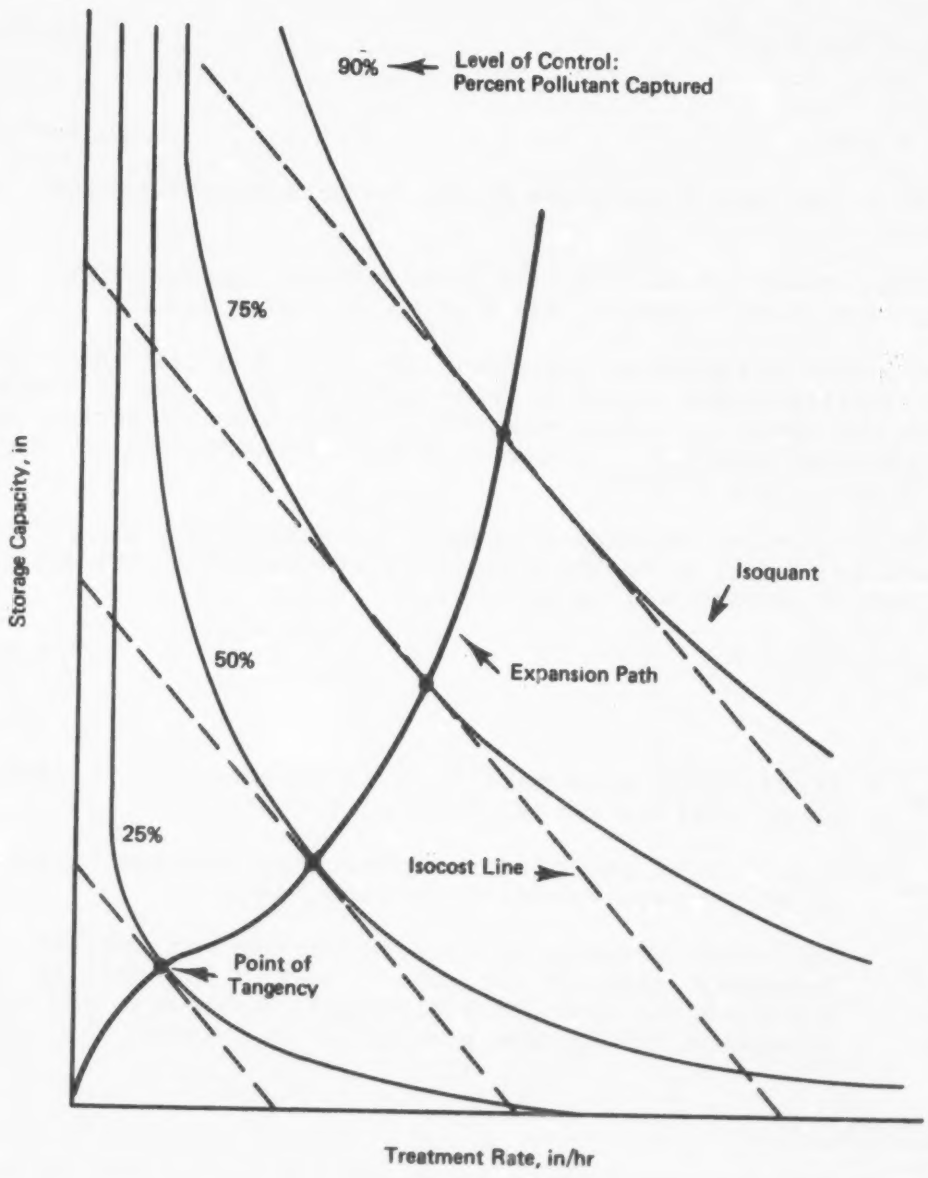

FIGURE 6-1. Definition sketch of storage/treatment production function.

The terms $T_2 - T_1$ and K are defined by the following empirical equations derived from analysis of isoquants developed from simulation of the rainfall/runoff and storage/treatment process for cities located in various regions of the country.[1]

$$T_2 - T_1 = be^{hc} \tag{6-3}$$

$$K = de^{-fc} \tag{6-4}$$

where b, h, d, and f are parameters defined by regression analysis.

Values for these parameters for five cities representing various hydrologic regions are listed in Table 6-1.

Utilizing the parameters presented in Table 6-1 for the region of the country under consideration and the mean annual runoff (AR) of the specific urban watershed under consideration, approximate storage/treatment isoquants may be constructed for any study site in the nation.

Once the pollutant capture is known, as determined from the isoquant analysis, then the pollutant removed from the receiving water may be determined as follows.

$$FR_{st} = C_{st} \cdot E_{st} \tag{6-5}$$

where

FR_{st} = Fraction of pollutant removed by storage treatment on an average annual watershed basis.

C_{st} = Fraction of pollutants captured by storage treatment on an average annual watershed basis.

E_{st} = Pollutant removal efficiency of the wet weather treatment facility by constituent. Approximate removal efficiencies for seven treatment processes and five treatment trains are presented in Chapter 5.

STREETSWEEPING

Streetsweeping has received a great deal of attention during the last few years as a potential water quality control management practice. More is known about streetsweeping costs and effectiveness than is known about any other potential management control for existing urban areas.

Streetsweeping has the major advantage of being applicable to highly developed, established urban areas. It also controls pollutants at the source and will improve general urban aesthetics

Table 6-1
Values of Parameters and Correlation Coefficients for Isoquant Equations for Percent BOD Capture with First Flush (after Heaney, et al.[1])

	b	h	d	f	Correlation	Coefficient
	in hr^{-1}	$(\% C)^{-1}$	in^{-1}	$(\% C)^{-1}$	$T_2 - T_1 = be^{hc}$	$K = de^{-fC}$
San Francisco	0.0021654	0.0388910	211.2763	0.0320226	0.9893	-0.9898
Denver	0.0013631	0.0439822	184.9639	0.0279177	0.9903	-0.9926
Minneapolis	0.0013656	0.0481981	241.6141	0.0301648	0.9956	-0.9958
Atlanta	0.0025864	0.0468175	190.2240	0.0312484	0.9857	-0.9899
Washington, D.C.	0.0018959	0.0487876	228.8434	0.0339322	0.9933	-0.9896

as well as water quality. However, streetsweeping is relatively inefficient as a pollution control measure because, even under the most favorable circumstances, only that portion of the total pollution load located in or near street gutters can be removed. Therefore, streetsweeping will be more effective for watersheds served by separate sewers than for watersheds served by combined sewers.

A review of the literature was undertaken in order to identify those factors which are significant to a streetsweeping program and to establish a procedure by which streetsweeping effectiveness (i.e., production functions) can be estimated. Factors which were determined to be important are listed as follows.

1. Type of sewer system.
2. Fraction of streets swept.
3. Streetsweeping frequency.
4. Total impervious area.
5. Impervious area due to streets.
6. Efficiency of streetsweeper.

BOD has generally been the parameter of interest for evaluating the effectiveness of streetsweeping as a water quality management technique. However, enough information is available to address several other constituents. Therefore, a general procedure for evaluation of alternative streetsweeping programs and construction of streetsweeping production functions will be developed here. This procedure provides a means whereby overall removal efficiencies for total solids, volatile solids, BOD, COD, TKN, nitrates, phosphates, and heavy metals can be evaluated.

In the most general case, the fraction of total watershed pollutants removed by streetsweeping can be expressed as follows.

$$FR_{sw} = Fsw \cdot \phi sw \cdot Ysw \qquad (6\text{-}6)$$

where

FR_{sw} = Fraction of pollutant removed by streetsweeping on an average annual watershed basis.

Fsw = Fraction of streets swept.

ϕsw = Sweeping availability factor.

Ysw = Fraction of pollutants available to the streetsweeper which are removed by sweeping.

The factor Fsw, fraction of streets swept, may reflect current streetsweeping practice within a community, or it may be an indicator of the type of streets existing within a given watershed. For example, it may be current practice to sweep only certain major downtown streets with the remainder receiving no attention. In this case, the factor Fsw represents the ratio of the area of streets actually swept to the total street area.

Streetsweeping is effective only on streets where pollutants accumulate which, in general, is on streets constructed with curbs. Thus, the sweeping of streets without curbs would be largely ineffective. For this reason, the maximum practical streetsweeping program would be to sweep all curbed streets. In this case, the factor Fsw would represent the ratio of area of curbed streets to total street area. The value of Fsw will range from near 0.0 in some low density suburban areas which were developed without curbed streets to near 1.0 in high density urban or downtown commercial areas, served entirely by curbed streets.

Evaluation of the sweeping availability factor, ϕsw, requires several assumptions regarding the distribution of pollutants within the watershed. It is generally accepted that most pollutant surface washoff from urban areas is associated with the impervious portion of the watershed.

Given that pollutant accumulation is significant only on impervious areas, it then becomes important to determine the distribution of this material within the impervious portion of the watershed. Data related to the distribution of pollutants are not available. However, it is probable that a disproportionate amount of the material is located on the streets or is delivered to the streets prior to final entry into the storm drainage system. Heaney and Nix (1977)[2] developed a relationship between the streetsweeping availability factor ϕsw and population density, assuming that pollutants are uniformly distributed over the impervious portions of the watershed. Such an assumption would, however, tend to underestimate pollutant availability. A more accurate representation would be to assume that surface loadings are twice as great on street surfaces as on other impervious surfaces. This assumption was made in the 1976 Needs Survey for control of pollution from combined sewer overflow and urban storm-water runoff.[3] Utilizing the above assumption, a relationship between total impervious area and population density developed by Stankowski[4] and a relationship between area of streets and population density reported by Heaney, Huber, and Nix (1976),[5] the following relationship between the availability factor, ϕsw, and population density may be derived.

$$\phi sw = \alpha_{sw}(0.67 - 0.00762PD) \qquad (6\text{-}7)$$

where

ϕsw = Streetsweeping availability factor which is the ratio of the pollutant available in the streets to the total watershed pollutant load.

α_{sw} = Sewer system type factor.

PD = Watershed population density in persons per acre.

For comparison purposes, an equation similar to the above equation was derived based on the assumption of uniform pollutant distribution. This equation is expressed as follows.

$$\phi sw = \alpha_{sw}(0.50 - 0.00762PD) \qquad (6\text{-}8)$$

The above equation is presented only to illustrate the sensitivity of the pollutant distribution assumption.

The α_{sw} or sewer system type factor is equal to 1.0 for watersheds served by storm sewers because all pollutant accumulation occurs on the watershed surface. In combined sewers, a substantial portion of the pollutants accumulate directly in the collection system and are therefore unavailable to the streetsweeper. The α_{sw} factor is, therefore, the ratio of surface accumulation to total watershed accumulation. For combined sewers, α_{sw} is assumed to be equal to 0.24 for BOD, SS, TKN, and PO_4 and equal to 1.0 for Pb.

The final factor appearing in the streetsweeping availability, factor equation Ysw, factor of available pollutant removed by the streetsweeper, is a function of rainfall characteristics, sweeping frequency, and streetsweeper pickup efficiency. Adimi, et al. (1976)[6] evaluated the effectiveness of streetsweeping in the Washington, D.C., area by use of simulation. The results of this study were presented as a family of curves (production functions) relating frequency of sweeping and pickup efficiency to percentage of BOD removed from the street gutters (Ysw). Heaney and Nix[2] performed a similar simulation study using Minneapolis rainfall data. This study resulted in development of a more complete set of production functions which are presented in Figure 6-2.

A review of the literature[2,6-9] concerning streetsweeper pickup efficiencies was conducted in order to establish typical values for various constitutents. The results of this review are reported in Table 6-2.

There are two types of streetsweepers in general use. These are broom type and vacuum type. The vacuum type does a better job of picking up fine material and, thus, has higher pollutant pickup efficiencies, as shown in Table 6-2. Most efficiency values for the broom-type sweeper were derived from data developed

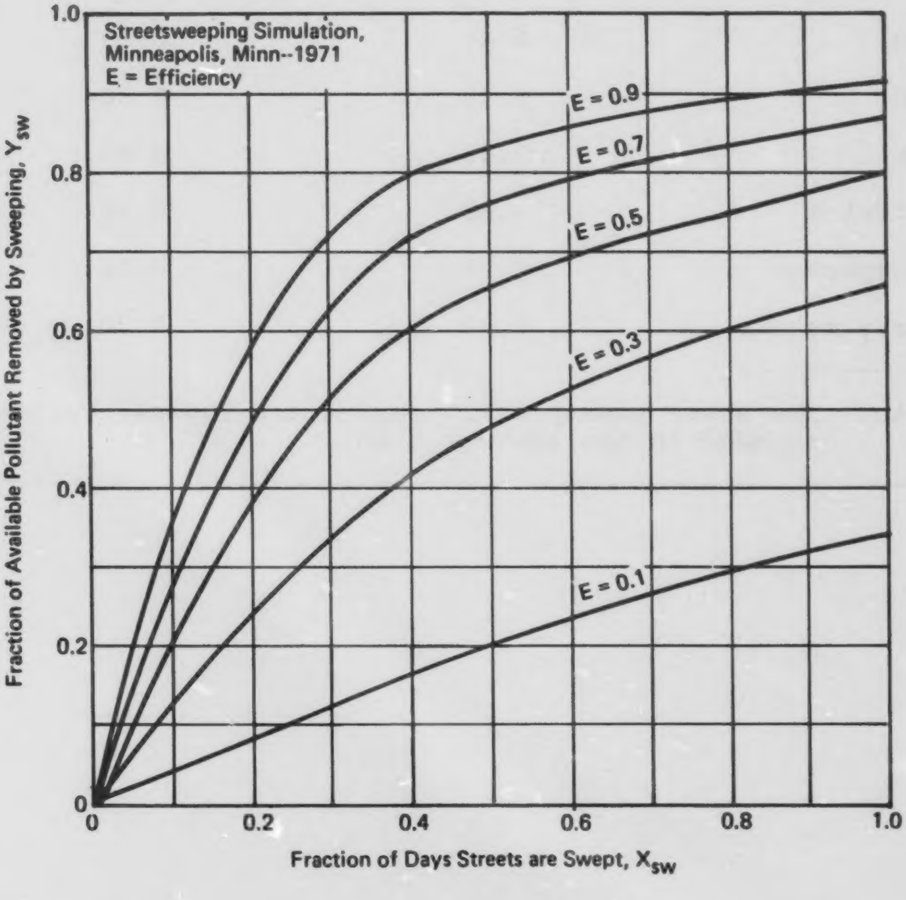

FIGURE 6-2. Production functions for streetsweeping.

Table 6-2
Estimated Pickup Efficiencies (E)
by Streetsweeper Type and Constituent

Constituent	Type of Streetsweeper	
	Broom	Vacuum or Broom/ Vacuum Combination
Total solids	0.55	0.80
Volatile solids	0.50	0.80
BOD_5	0.45	0.80
COD	0.30	0.80
TKN	0.45	0.80
Nitrates	0.35	0.70
Phosphates	0.20	0.70
Heavy metals	0.50	0.90

Note: The above pickup efficiencies are typical values rounded to the nearest 0.05.

by Sartor and Boyd[9] as reported by Heaney and Nix.[2] Efficiency values for vacuum-type sweepers were estimated by extrapolation of the Sartor and Boyd data and by comparison of these estimates with typical values reported by Field, et al.[7]

The streetsweeping production function used in the 1978 Needs Survey is presented in Figure 6-3. This streetsweeping production function was developed from an areawide 208 study performed in Illinois, assuming a streetsweeper with an 80% pickup efficiency.[10]

The Management of Urban Nonpoint Pollution (MUNP) Model[11,12] was used to evaluate the pollutant removal effectiveness of streetsweeping operations. The MUNP model is a continuous planning model that can simulate the physical processes of nonpoint source pollutant accumulation, washoff, and control. The MUNP model uses the streetsweeping equations developed by Sutherland and McCuen.[11] The effectiveness of streetsweeping in removing total solids and associated pollutants is a function of the accumulated material in each particle size range, the type of sweeper (i.e., broom type or vacuum), and the forward speed of the sweeper. The data used in the development of the MUNP model's streetsweeping component were obtained by the U.S. Naval Radiological Defense Laboratory[13,14] which conducted a series of tests designed to evaluate the effectiveness of broom-type and vacuum streetsweepers in removing particulate material.

The streetsweeping production function shown on Figure 6-3 was developed from data obtained from several simulations with the MUNP model. 1960 hourly rainfall data for Champaign-Urbana and a modified version of the Illinois State Water Survey's nonlinear street solids accumulation curve for commercial land uses[15] were inputs to the continuous model. A streetsweeper operating at a forward speed of 6 miles per hour was assumed. Successive simulations of the MUNP model in which the streetsweeping frequency was the only variable changed provided annual BOD removals (i.e., expressed as a fraction of the available BOD street surface loading, Y_{sw}) for several levels of sweeping effort (i.e., expressed as the fraction of days streets are swept, X_{sw}). A curve was fit to the data generated by the simulation.

Figure 6-3 also shows a comparison of the Minneapolis, Minnesota, and the 1978 Needs Survey streetsweeping production functions for an 80% pickup efficiency.

The procedure for estimating the overall reduction of pollutant loading due to a given streetsweeping program may be summarized in four steps.

1. For the constituent of interest and a known sweeper type, select the appropriate efficiency, E, from Table 6-2.

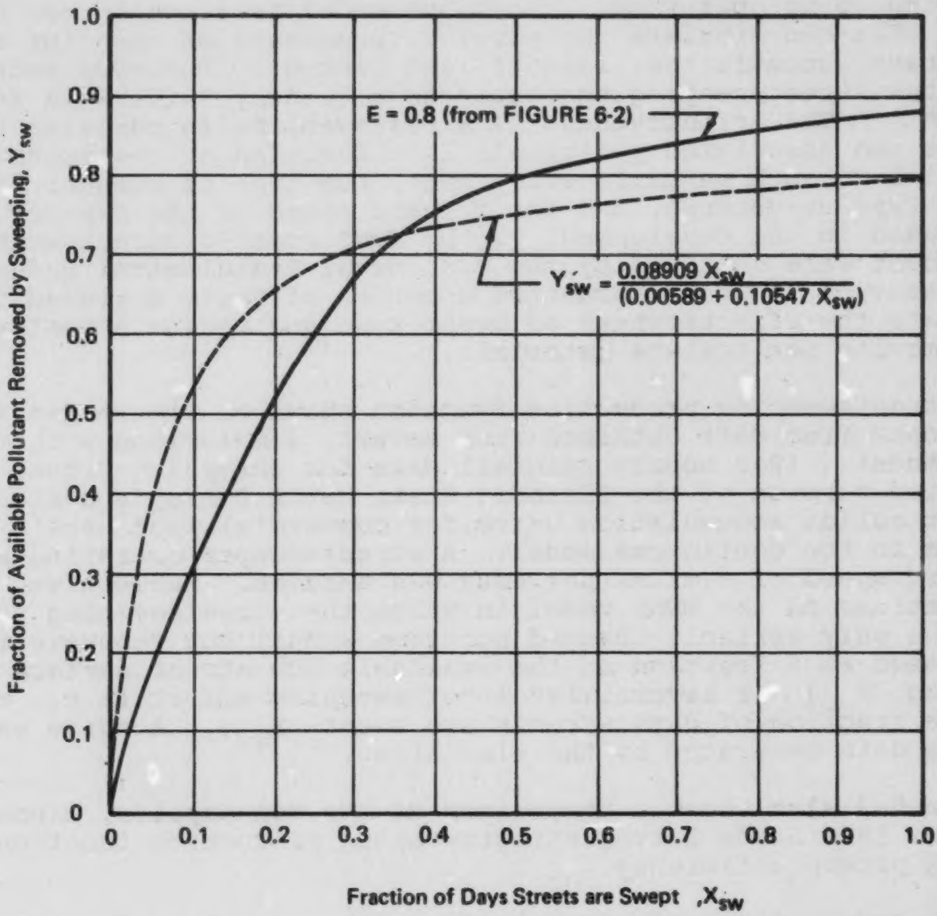

FIGURE 6-3. Streetsweeping production function for economic optimization.

2. Knowing E and the frequency of streetsweeping, determine the fraction of available pollutant removed by sweeping, Ysw, from Figure 6-2 or 6-3.

3. Using the population density of the watershed, PD, and knowing the type of collection system, estimate the streetsweeping availability factor, ϕsw.

4. Compute fraction of pollutant removed, FR.

The cost of streetsweeping has been reported to range from \$3.00 to \$13.00 per curb mile.[8] The mean value reported by a recent APWA survey is \$7.00 per curb mile.[2] This value was also used in the 1976 Needs Survey[3] to estimate total national cost of streetsweeping. A unit cost of streetsweeping of \$10.00 per curb mile swept is used in the 1978 Needs Survey. This value includes the cost of ultimate disposal of the collected material.

SEWER FLUSHING

Sewer system flushing is a collection system management technique which is applicable to combined sewer systems, since most pollution accumulation in combined systems occurs in the collection system rather than on the watershed surface. Sewer flushing consists of introducing a controlled volume of water over a short duration at key points in the collection system. The flushing waters will resuspend deposited solids and transmit these solids to the dry weather treatment facility for treatment.

The most extensive recent research on sewer flushing has been reported by Pisano and Queiroz.[16] A generalized sewer flushing production function developed from this research was reported by Heaney and Nix.[2] This production function is shown as the solid line in Figure 6-4. The dashed line in Figure 6-4 shows the mathematical representation of the sewer flushing production function used to optimize wet-weather pollution control costs in Chapter 9.

The fraction of total watershed pollutants removed by sewer system flushing may be expressed as follows:

$$FR_{sf} = \phi_{sf} \cdot E_{sf} \cdot E_{wwtp} \cdot Y_{sf} \qquad (6\text{-}9)$$

where

FR_{sf} = Fraction of pollutant removed by sewer flushing on an average annual basis.

ϕ_{sf} = Sewer flushing availability factor.

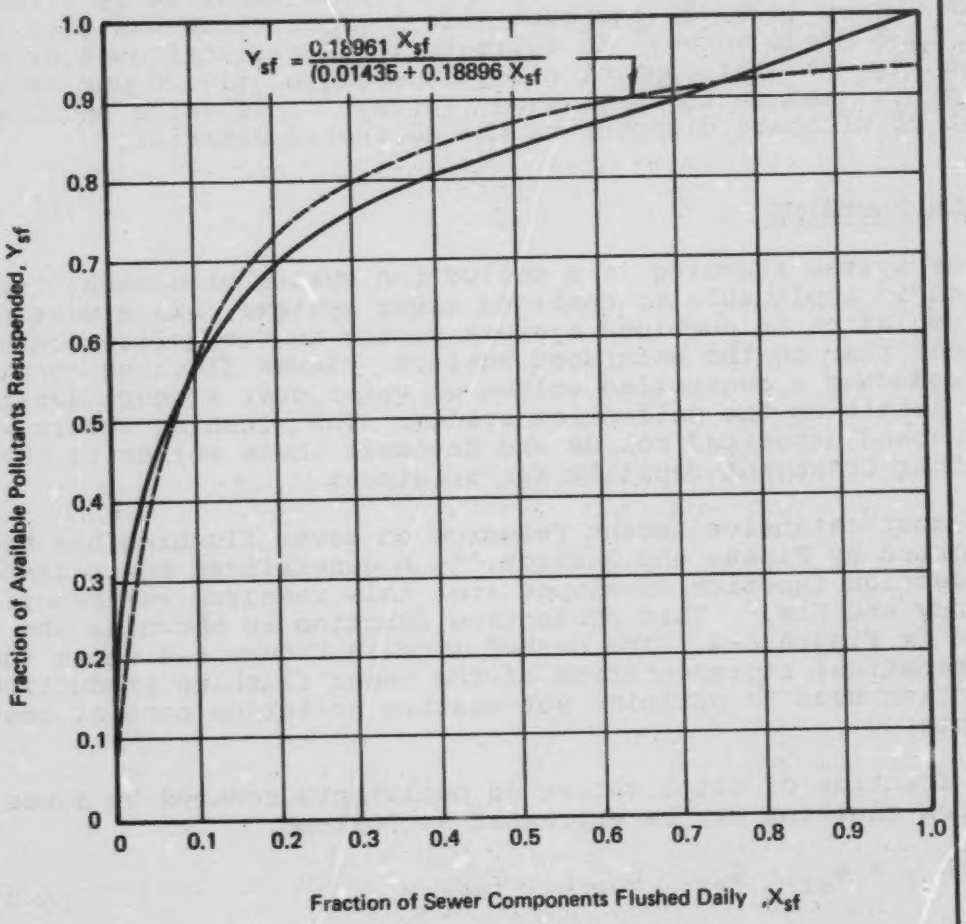

FIGURE 6-4. Production function for combined sewer flushing.

E_{sf} = Efficiency of sewer flushing, defined as the ratio of the amount of pollutants delivered to the WWTP to the amount of pollutants resuspended.

E_{wwtp} = Pollutant removal efficiency of the wastewater treatment plant.

Y_{sf} = Fraction of pollutants available in the collection system, which are resuspended by flushing.

The sewer flushing availability factor, ϕ_{sf}, is equal to 0.76 for BOD, SS, and TKN and is equal to 0.0 for lead. These values imply that approximately 3/4 of the BOD, SS, and TKN found in combined sewer systems accumulates in the collection system, whereas all of the lead accumulates on the surface and is, therefore, unavailable for flushing.

Preliminary results indicate that sewer flushing removal effectiveness, E_{sf}, ranges from 0.75 to 0.90.[16] For the purpose of the 1978 Needs Survey, a value of 0.83 was used in all computations.

The pollutant removal efficiency of the wastewater treatment plant, E_{wwtp}, is independent of the sewer flushing program but must be accounted for, since the final objective is to prevent pollutants from entering the receiving water. Typical values for secondary treatment are 0.85 for BOD and SS.

The fraction of pollutants which are resuspended by sewer flushing, Y_{sf}, is a function of the level of effort of the sewer flushing program. This effort is expressed as the fraction of sewer components flushed daily and is represented by the production function illustrated in Figure 6-4.

SEWER SEPARATION

A review of the available literature failed to produce a production function for sewer separation or data which could be used to define such a function. It is reasoned, however, that sewer separation may be addressed in a manner similar to the procedures developed for streetsweeping and sewer flushing. Thus, the fraction of total watershed pollutants removed by sewer separation may be expressed by the following equation.

$$FR_{sep} = \phi_{sep} \cdot E_{wwtp} \cdot Y_{sep} \qquad (6\text{-}10)$$

where

FR_{sep} = Fraction of total watershed pollutants removed by combined sewer separation.

ϕ_{sep} = Combined sewer separation availability factor.

E_{wwtp} = Pollutant removal efficiency of the wastewater treatment plant.

Y_{sep} = Fraction of pollutants available in the collection system, which are transmitted to the wastewater treatment plant by combined sewer separation.

The sewer separation availability factor, ϕ_{sep}, is identical to the sewer flushing availability factor, ϕ_{sf}, since both factors represent the ratio of pollutants available in the collection system to total watershed pollutants. This factor is equal to 0.76 for BOD, SS, and TKN and is equal to 0.0 for lead.

Y_{sep}, the fraction of available pollutants transmitted to the WWTP, is a function of the degree of combined sewer separation. If the assumption is made that pollution accumulation is uniform over the watershed, then Y_{sep} is equal to the fraction of sewer components separated on an area basis. Thus, the production function for combined sewer separation may be considered linear, as illustrated in Figure 6-5.

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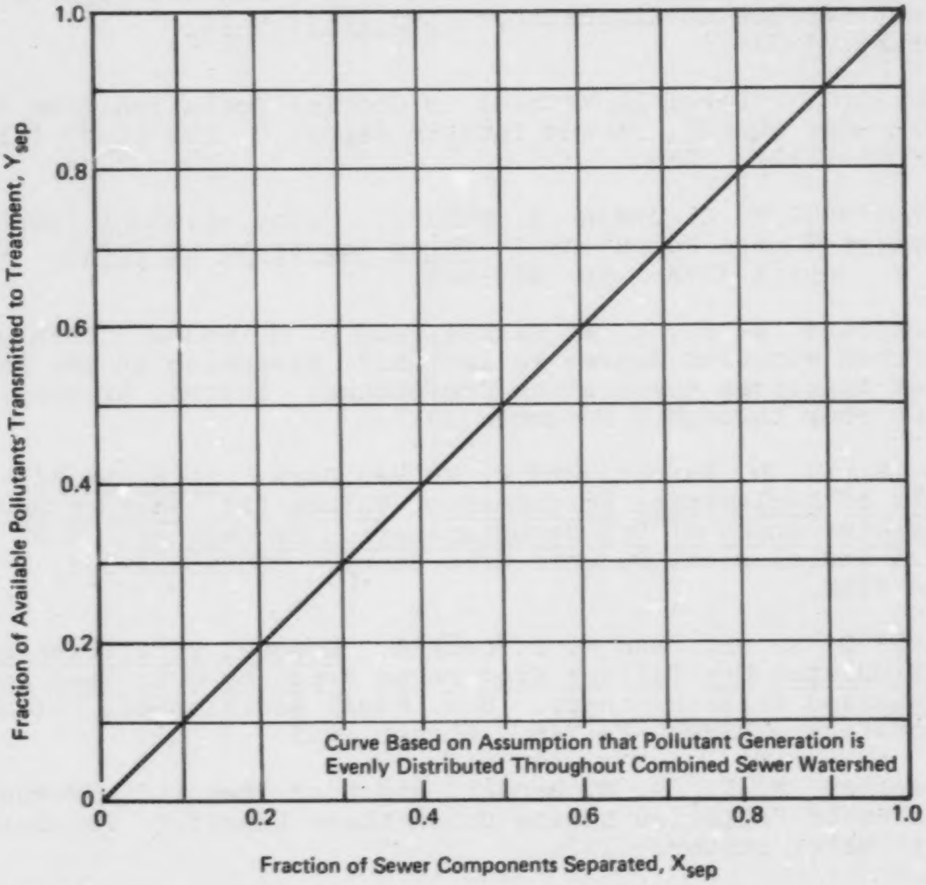

FIGURE 6-5. Production for combined sewer separation.

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PART III

SITE STUDIES

Chapter 7
OUTLINE OF CONTINUOUS STORMWATER POLLUTION SIMULATION SYSTEM (CSPSS)

The Continuous Stormwater Pollution Simulation System (CSPSS) was developed for use in the 1978 Facilities Needs Estimate for Control of Pollution from Combined Sewer Overflow (CSO), Category V, and from Urban Stormwater Runoff, Category VI. The CSPSS model was used to perform a continuous macroscopic analysis of 14 of the 15 urban study sites to estimate the impact of CSO and urban stormwater on a receiving river or river/estuary. The receiving water of the 15th urban study site, Syracuse, New York, is a lake, and CSPSS does not apply in this case.

The three main objectives of these studies were to determine (1) if a particular urban area/receiving water system is presently experiencing a receiving water quality water problem, (2) how much of the problem, if any, is due to CSO and urban stormwater runoff, and (3) the level of pollutant removal required to achieve selected water quality goals. A summary of the 15 site studies is presented in Chapter 8 and complete site study results are presented in Appendix A. This chapter will present only a brief description of the CSPSS since a separate document provides a detailed development of the model, including computer coding instructions and a complete Fortran listing.[1]

SYSTEM STRUCTURE

The Continuous Stormwater Pollution Simulation System is structured as a series of modules, each designed to perform a certain set of hydrologic or water quality computations. These modules are nested; that is, output of one may become input to another. In some cases, more than one option is available to perform a given function, and the system is structured so that additional modules may be developed and added in the future with a minimum of changes to the existing modules.

Basic functions which may be simulated on a continuous basis are listed as follows.

1. Local rainfall.
2. Local runoff.
3. Pollutant washoff.

4. Sewer system infiltration.
5. Storage/treatment.
6. Dry-weather wastewater flow.
7. Receiving water streamflow.
8. Receiving water quality response.

These modules may be executed in logical sequential order to produce the desired simulation. A general flow chart of the simulation system is shown in Figure 7-1.

The numbers given in each box on Figure 7-1 are module identifiers which are associated with each computation routine. The series 10 through 50 (rainfall through storage/treatment) constitutes the urban runoff and combined sewer system pollution generation simulation. The 60 module and 70 module generate wastewater treatment flow and upstream receiving water flow, respectively. Output from the 10 through 50 series and modules 60 and 70 are input to module 80 which computes receiving water quality resulting from these inputs.

COMPUTATIONAL SEQUENCE

The basic computational sequence involves the generation of a number of annual arrays. The first array is the annual rainfall array, developed in the rainfall module (10), which drives the remainder of the urban runoff pollution generation sequence.

The runoff module (20) converts the rainfall array to a runoff array which represents the hydrologic response of the urban area. Either one or two watersheds may be represented; therefore, either one or two runoff arrays may be generated.

The washoff module (30) simulates the processes of pollution accumulation and subsequent pollutant washoff for four constituents: suspended solids (SS), 5-day biochemical oxygen demand (BOD_5), total kjeldahl nitrogen (TKN), and lead (Pb). Thus, four runoff quality arrays are defined for each watershed.

The sewer system infiltration module (40) is optional and applies to sewer systems subject to infiltration-induced overflow. This module will generate an infiltration array based on the recent time history of daily rainfall. Quality arrays for SS, BOD, TKN, and Pb are also developed, and these arrays are combined with the runoff quantity and quality arrays.

The storage/treatment module (50) simulates the effects of a storage/treatment system on the runoff sequence and on runoff quality.

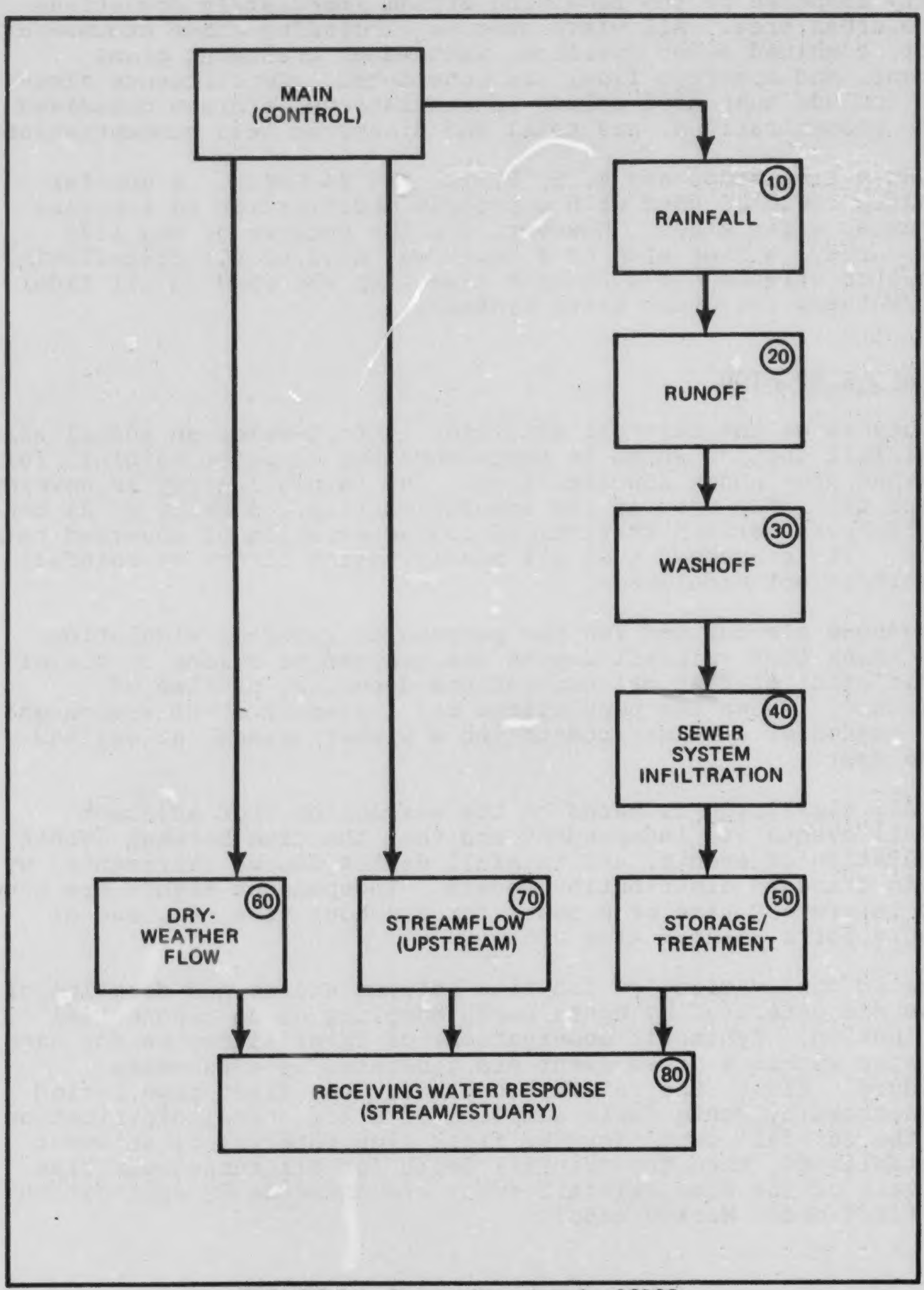

FIGURE 7-1. General flow chart for CSPSS.

The receiving water response module (80) determines the water quality response of the receiving stream immediately downstream of the urban area. All waste sources, including urban stormwater runoff, combined sewer overflow, wastewater treatment plant effluent, and upstream flow, are considered. Constituents simulated include suspended solids concentrations, minimum dissolved oxygen concentrations, and total and dissolved lead concentrations.

Allowable time steps are 4, 6, 8, 12, and 24 hours. A shorter time step could be used with a program modification to increase all annual array sizes. However, for the purpose of the 1978 Needs Survey, a time step of 4 hours was used on all free-flowing freshwater streams and a 24-hour time step was used on all tidal river/estuary receiving water systems.

RAINFALL SIMULATOR

The purpose of the rainfall simulator is to develop an annual array of rainfall depths, which is representative of point rainfall for the urban area under consideration. The rainfall array is developed for the time step used in the simulation (i.e., 4 hours or 24 hours) and preserves certain statistical characteristics of observed rainfall events. It is assumed that all precipitation occurs as rainfall. Snowmelt is not simulated.

Two seasons are defined for the purpose of rainfall simulation, which means that rainfall depths are assumed to belong to one of two different statistical populations depending on time of occurrence. These two populations may represent a wet season and a dry season or a summer season and a winter season, as defined by the user.

Rainfall simulation is based on the assumption that adjacent rainfall events are independent and that the time between events, the duration of events, and rainfall depths can be represented by certain standard distribution models. Independent events are based on an interevent time of 8 hours for a 4-hour time step and of 24 hours for a 24-hour time step.

Synthetic observations of the time between storms and duration of storms are generated by Monte Carlo sampling of an exponential distribution. Synthetic observations of rainfall depths for each time step within a given event are generated by a two-step procedure. First, the rainfall depth for the first time period is generated by Monte Carlo sampling of a log-normal distribution. Once the rainfall depth for the first time interval of an event is established, then the rainfall depth for all subsequent time intervals of the same rainfall event are computed by application of a first-order Markov model.

WATERSHED RUNOFF

The purpose of this portion of the simulation is to transform the annual rainfall array into an annual runoff array. One or two runoff arrays may be generated. In general, one runoff array will represent the hydrologic response of the urban area served by combined sewers, and the other runoff array will represent the hydrologic response of the urban area served by separate sewers. However, in the case of an urban area which does not have any combined sewer service area, the user has the option of generating two runoff arrays, each of which represents the hydrologic response of a portion of the urban area, or the user may generate only one runoff array which represents the entire urban area.

The method used is based on a rainfall runoff relationship developed by the Soil Conservation Service (SCS). The SCS rainfall/runoff relationship was chosen because it is a simple relationship which accounts for the major factors influencing direct surface runoff, such as land use, soil type, antecedent rainfall, initial losses, and variation of the rainfall/runoff ratio during a given event. Other simpler relationships, such as the rational method, do not account for all of the above factors, and more sophisticated procedures require continuous soil moisture accounting which is computationally complex and requires detailed knowledge of watershed characteristics.

Once the runoff arrays are generated, then a simple hydrologic routing (time-area) may be applied to each array to account for watershed storage. This step will redistribute the flows with respect to time. However, the total volumes will remain unchanged.

POLLUTION ACCUMULATION AND WASHOFF

The objective of the pollution accumulation and washoff module is to simulate the process of pollutant accumulation or buildup on the watershed during dry periods and subsequent pollutant washoff during periods of runoff. Pollutants considered are those which are evaluated in the receiving water impact analysis and include suspended solids (SS), 5-day biochemical oxygen demand (BOD_5), total kjeldahl nitrogen (TKN), and lead (Pb). The accumulation and removal of each of the above pollutants are computed for each time step in the year, and annual quality arrays for each are developed.

The watershed pollutant accumulation function can be specified as a linear or nonlinear buildup, depending on the pollutant decay rate. For the purposes of the 1978 Needs Survey, it was assumed that oxygen-demanding materials, i.e., BOD and TKN, will reach maximum accumulation in 15 days and that non-oxygen-demanding materials, i.e., SS and Pb, accumulate in a linear fashion. Pollutant accumulation rates are calculated using the SWMM Level 1 equations[2] unless field data are available.

Watershed pollutant washoff at the end of any time period is a function of the pollutant accumulation at the end of the previous time period and of the runoff during the time period. The functional form of this relationship utilized in CSPSS is the classical exponential decay curve.

SEWER SYSTEM INFILTRATION

The purpose of the infiltration component is to construct an annual array of daily excess sewer infiltration values for wastewater collection systems. This array is added to the runoff array before processing by the storage/treatment model or receiving water model. Thus, it is primarily intended for use in combined sewer systems.

The infiltration module is optional and should be used when there is evidence that infiltration alone will cause treatment plant bypass or overflow and when the annual quantity of such overflow is known or can be estimated.

Sewer system infiltration rates depend on many factors such as soil type, ground-water table elevations, type of collection system, and age and condition of collection system as well as local rainfall. No general mathematical models are available which account for all of the above parameters. Therefore, simulation of sewer system infiltration is subject to much uncertainty, and the results must be reviewed by the user for reasonableness.

Total infiltration quantity is computed from the rainfall array by an empirical equation developed from analysis of observed rainfall and infiltration data for the City of Baltimore, Maryland.[3] Infiltration is assumed to be pure water which mixes with and dilutes sanitary wastewater in the collection system.

STORAGE/TREATMENT

The purpose of the storage/treatment module is to modify the runoff quantity and quality arrays in such a manner as to simulate the operation of stormwater runoff storage and treatment facilities.

Computation of storage, treatment, and overflow is accomplished on a simulation time step basis throughout the year. For every time period in which runoff occurs, the treatment facilities are utilized to treat as much runoff as possible. When the runoff rate exceeds the treatment rate, storage is utilized to contain the runoff. When runoff is less than the treatment rate, the excess treatment rate is utilized to diminish the storage level. If the storage capacity is exceeded, all excess runoff is considered overflow and does not pass through the storage facility. This overflow is discharged to the receiving water and cannot be treated later. The treated runoff array is then added to the overflow array and the combined quality is computed to produce the new modified runoff arrays.

The quality of the runoff waters in storage is considered to be the quality of the composite mixture during any time step. Thus, storage will have an attenuation effect on both the quantity and quality of runoff. However, actual removal of pollutants from the runoff waters in storage is not simulated directly. Thus, the treatment which occurs in storage is assumed to be negligible or may be accounted for by adjustment of the removal efficiencies assigned to the treatment processes.

The physical, chemical, and biological aspects of wastewater treatment are not simulated directly in this module. Instead, effluent quality for each constituent is computed by application of a user-supplied treatment efficiency to the stored runoff waters.

DRY-WEATHER WASTEWATER TREATMENT PLANT FLOW

The purpose of the dry-weather flow module is to create an array of flow values which represents base wastewater flow generated by the entire urban area. Both domestic and industrial waste sources should be considered. Average values of wastewater effluent quality for SS, BOD, TKN, and Pb are applied to the time variant flow array to generate representative dry-weather point source wasteloads to the receiving water.

Dry-weather point source flow magnitude is varied by hour of the day and by day of the week by application of the appropriate flow ratios. These flow ratios are multiplied by the mean dry-weather wastewater effluent flow rate to obtain a representative time variant flow rate. The ratios used are the national average default values used in the "STORM" model.[4]

UPSTREAM FLOW

The purpose of the streamflow modules is to provide an array of flow values which are representative of the upstream flow entering the urban area. Only quantitative aspects of the upstream flow are considered in this portion of the simulation system. Upstream water quality data are input with the receiving water module.

There are two options available for upstream flow. The first (module 70) reads in and stores an array of observed daily flow values for a period of up to 5 years. The second (module 71) is a stochastic streamflow simulator which will generate synthetic values of monthly flows. Module 71 is similar in structure to the synthetic rainfall generator.

For the purposes of the Needs Survey, module 70 was used since the time distribution of streamflow is better defined on a daily basis than on a monthly basis.

The term "upstream flow," as used here, refers to all waters entering the upstream boundary of the urban area which are available to blend with the local urban runoff, combined sewer overflow, and wastewater treatment plant effluents. These flows may be generated by one or more major streams, as illustrated on Figure 7-2. Refering to Figure 7-2, flows Q_A and Q_B are the flows of interest, and their summation defines the upstream flow array which is to be read into or simulated by the model.

Several additional important concepts are illustrated in Figure 7-2. First, the receiving stream within the limits of the urban area is considered a mixing zone. This zone accepts the upstream flows and mixes these flows with the local urban-area-induced flows, including urban runoff, combined sewer overflow, and wastewater treatment plant effluent. These local flows are added to the upstream flow to produce the total outflow from the urban area, represented as Q_C on Figure 7-2. The total outflow (quantity and quality) from the urban area becomes the inflow to the receiving water response portion of the simulation.

RECEIVING WATER RESPONSE

The purpose of the receiving water response portion of the simulation is to compute the water quality of the receiving water on a continuous basis. Water quality parameters considered are (1) suspended solids concentrations, (2) minimum dissolved oxygen concentrations, and (3) total and dissolved lead concentrations. In addition, total annual discharge of all pollutants to the receiving water is determined.

The receiving water response module will generate the data required to construct a cumulative frequency distribution for each water quality parameter considered. Cumulative frequency curves may be developed for existing prototype conditions or for proposed conditions. The difference between existing condition and proposed condition curves can then be compared to quantify the receiving water quality impact of the proposed improvements.

Suspended Solids

Suspended solids are assumed to be a conservative substance during the time period required for inflows to mix. Thus, suspended solids concentration occurring in the receiving water during each time step is computed as the flow-weighted average of all suspended solids entering the mixing zone (see Figure 7-2) during that time step.

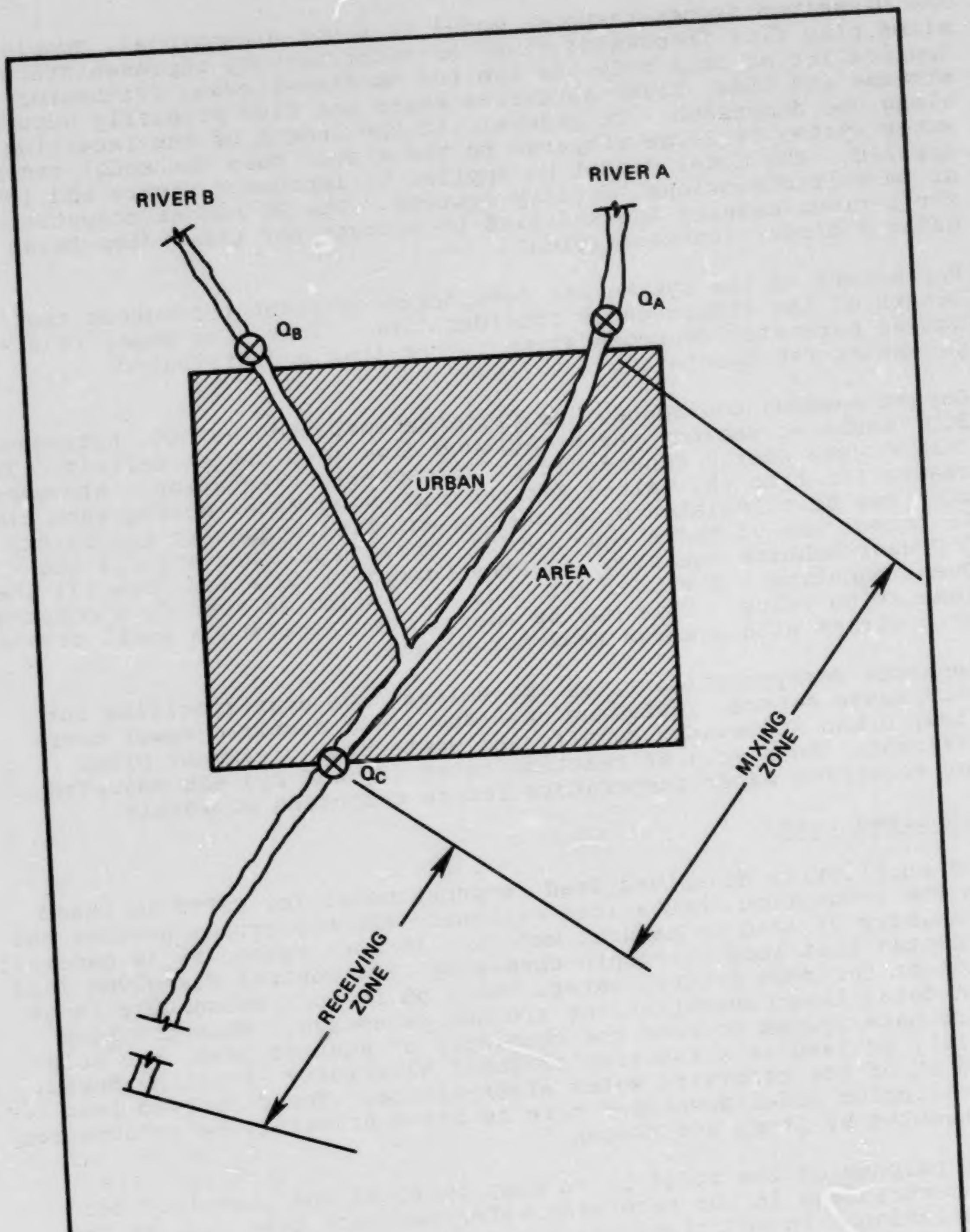

FIGURE 7-2. Definition sketch showing upstream flow, mixing zone, and receiving zone.

Dissolved Oxygen

The dissolved oxygen response model is a one-dimensional, completely mixed plug flow freshwater river or river/estuary representation. Application of this model is limited to free-flowing freshwater streams and tidal river estuaries where the flow primarily occurs along one dimension. In general, if the length of the receiving water system is large compared to the width, then the model can be applied. The model cannot be applied to impounded rivers and lakes or to multidimensional estuary systems. The DO budget computations for a river/estuary are modified to account for tidal dispersion using a dispersion coefficient.

Parameters of the system are considered constant throughout the length of the stream under consideration. Thus, the model is a lumped parameter representation rather than a distributed parameter representation.

Oxygen demands considered are ultimate carbonaceous BOD, nitrogenous BOD, sediment demand, and background dissolved oxygen deficit. The only oxygen source considered is atmospheric reaeration. Atmospheric reaeration rate (K_2 value) for the receiving water during each time step may be calculated by using the existing hydraulic conditions to select one of three equations.[5] These equations are (1) the O'Connor-Dobbins equation, (2) the Churchill equation, and (3) the Owens equation. The user also has the option to specify a constant reaeration value. This may be useful when modeling a small stream or a stream with a known reaeration rate.

Separate deoxygenation rates (K_2 values) are user-specified for each waste source, including upstream flow, combined sewer overflow, urban stormwater runoff, and wastewater treatment plant effluent. Both sets of reaction rates (K_1 and K_2) are adjusted for receiving water temperature before computing DO levels.

Dissolved Lead

The equilibrium dissolved lead response model for CSPSS is based on the assumption that a lead carbonate ($PbCO_3$) system governs the chemistry of lead in natural waters. In most cases, it is generally accepted that lead carbonate chemistry will control dissolved lead content for most natural waters where pH is in a reasonable range and total lead concentrations are not excessive. When the lead carbonate system governs the chemistry of aquatic lead, the solubility of lead is a function of total alkalinity, total hardness, and pH of the receiving water after mixing. The dissolved lead equilibrium model developed here is based primarily on information presented by Stumm and Morgan.[6]

The purpose of the model is to compute total and dissolved lead concentrations in the receiving water for each time step of the simulation. In addition, maximum annual 96-hour and time average mean dissolved lead concentrations are also computed.

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Chapter 8
SITE STUDIES FOR RECEIVING WATER IMPACT ANALYSIS

INTRODUCTION

The purpose of this chapter is to present (1) the criteria for selecting the 15 receiving water study sites, (2) the procedure for simulating receiving water quality, and (3) a summary of the results of the receiving water simulation. A complete presentation of the 15 site studies is presented in Appendix A.

The results of these site studies are analyzed in Chapter 10 to determine relationships between receiving water quality and pollutant removal requirements. These generalized relationships are then applied to the urbanized area data base in Chapter 11 to produce the national needs estimate for Categories V and VI.

SITE SELECTION

The criteria for selection of the 15 study sites were similar to the primary criteria reported in the 1976 Needs Survey[1] as follows.

1. Study sites were evenly distributed geographically throughout the United States.
2. Study sites were representative of the full population range of urban centers.
3. Ten sites were served by combined sewer systems and five were served by separate storm sewers only.
4. The sites were selected based on the availability of the following types of data.
    a. Water quality of stormwater/combined sewer runoff, including BOD_5, COD, nitrogen (NO_2, TKN), SS, coliforms, and heavy metals.
    b. Drainage area, level of development (percent impervious area) slope, soil type, etc., for tributary watershed.
    c. Continuous rainfall data at or near the site.
    d. Streamflow data for receiving water upstream of urban area.
    e. Water quality data for receiving water including DO, temperature, SS, coliforms, salinity, etc.

These site selection criteria were applied to 24 candidate combined sewer sites and 12 candidate stormwater sites. An extensive literature search was performed so that the potential study sites could be ranked according to the availability of data and the applicability of the Continuous Stormwater Pollution Simulation System (CSPSS, presented in Chapter 7). The two major sources of information for this literature search were the EPA Water Quality Management Information System[2] and the USGS National Water Data Exchange[3] (NAWDEX).

The Water Quality Management Information System tracks the progress of 76 areawide and 49 state 208 programs. Each 208 project profile stored on this system contains startup dates, major cities involved, a description of high priority problems, milestones for achieving solutions, and a narrative overview of proposed solutions.

The USGS NAWDEX has been established to assist users of water data in the identification, location, and acquisition of needed data. Its objectives are to provide the user with sufficient information to define what data are available, where these data may be obtained, and in what form they are available as well as to describe some of their major characteristics. NAWDEX is comprised of water-oriented organizations in the federal, state, and local governments and in the academic and private sectors of the water data community who work together to make their water data readily and conveniently available.

Data search and referral services are currently provided through the Program Office established by the USGS, which has the lead role responsibility for NAWDEX operations. A computerized Master Water Data Index has been created, which currently identifies more than 61,500 sites for which water data are available, the location of these sites, the hydrologic disciplines represented by the data, the media in which the data are available, and the organizations collecting the data.

Based on these site selection criteria, the 15 selected study sites are:

Group 1--Combined Sewer Systems (Figure 8-1)

Philadelphia, Pennsylvania
Atlanta, Georgia
Portland, Oregon
Rochester, New York
Bucyrus, Ohio
Des Moines, Iowa
Milwaukee, Wisconsin
Washington, DC
Sacramento, California
Syracuse, New York

Group 2--Separate Storm Sewers (Figure 8-2)

Durham, North Carolina
Castro Valley, California
Springfield, Missouri
Tulsa, Oklahoma
Ann Arbor, Michigan

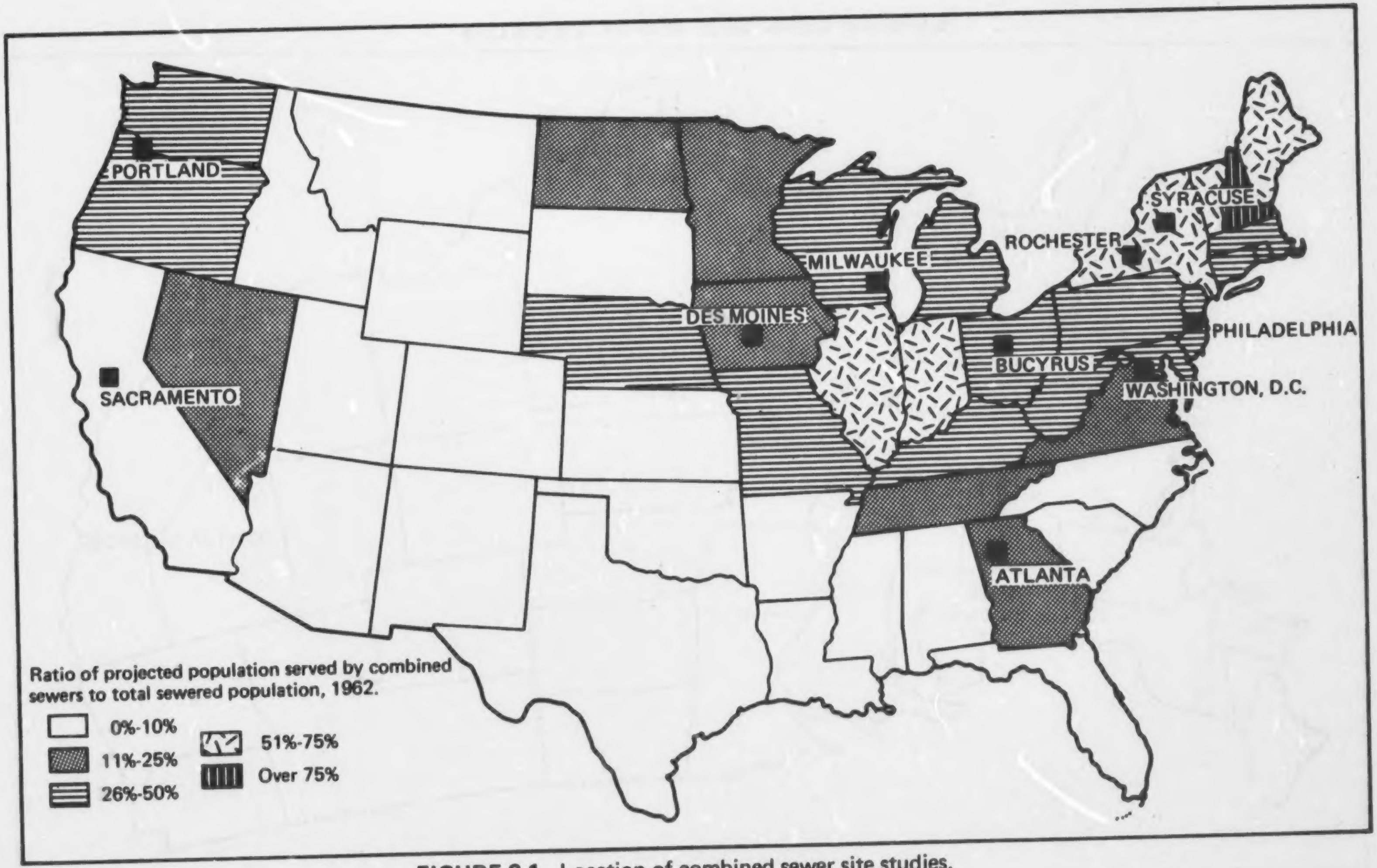

FIGURE 8-1. Location of combined sewer site studies.

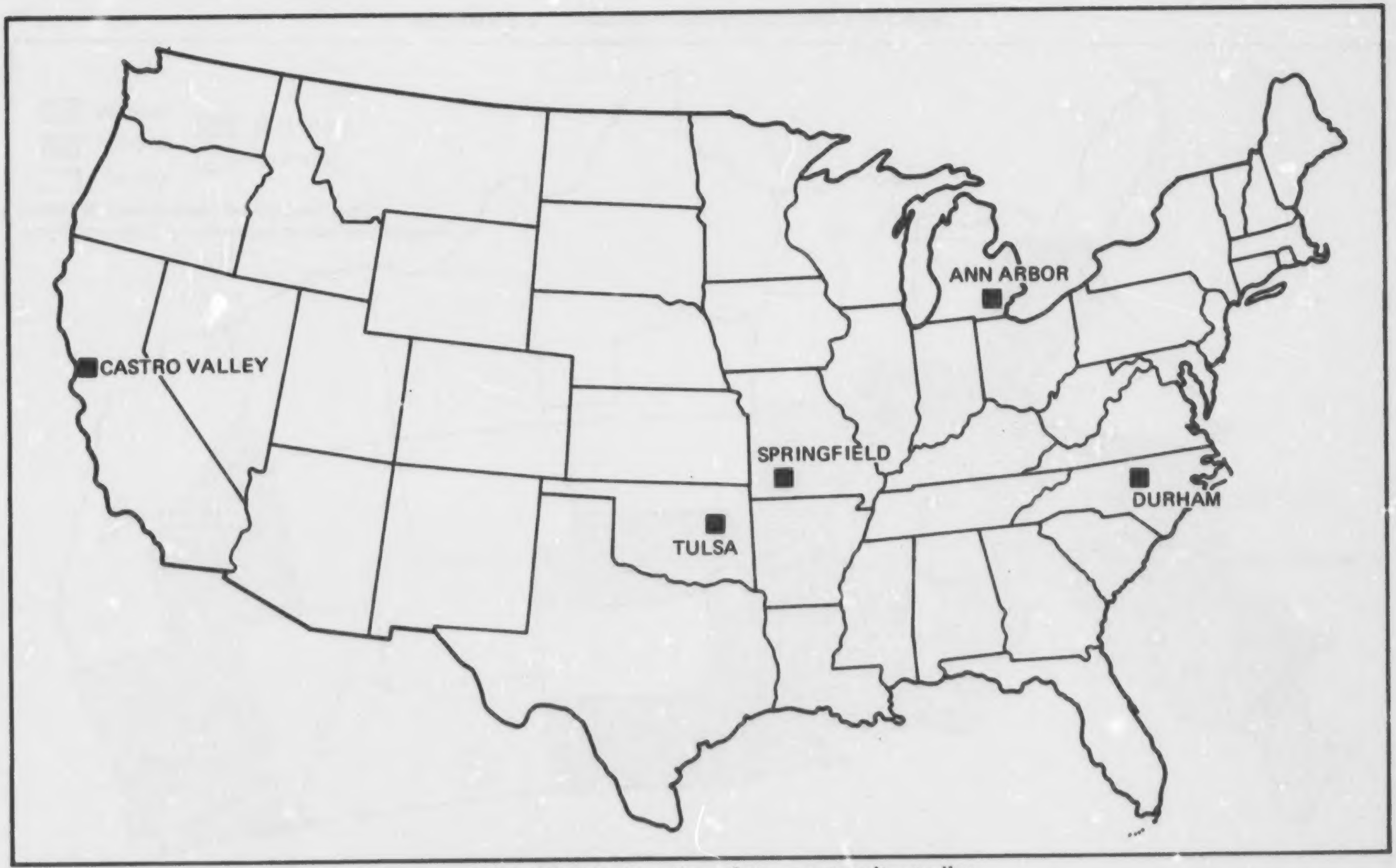

FIGURE 8-2. Location of stormwater site studies.

Figure 8-1 not only illustrates the distribution of the selected combined sewer sites but also shows the distribution of populations served by combined sewer systems. Seven of the 15 selected study sites were included in the 1976 Needs Survey: Atlanta, Georgia; Des Moines, Iowa; Durham, North Carolina; Milwaukee, Wisconsin; Philadelphia, Pennsylvania; Portland, Oregon; and Tulsa, Oklahoma.

SITE STUDY PROCEDURE

The analysis of pollutant removal requirements to meet the receiving water quality objectives presented in Chapter 2 was performed using the CSPSS described in Chapter 7.

Basically, the procedure consists of loading the site data module-by-module and testing each module before proceeding to the next. Since the modules of CSPSS are nested (i.e., output from one becomes input to another), it is not possible to adequately test one module until all modules preceding it are operating properly. For example, watershed pollution accumulation and washoff (module 30) cannot be calibrated until the runoff module (20) is generating a representative runoff sequence. Also, the runoff module cannot be calibrated until the generated rainfall sequence is determined to be representative of the study site.

Rainfall Module

Rainfall statistics from each study site are based on a 5-year sample of rainfall data from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). In general, the input rainfall statistics were considered representative when the 20-year simulation mean annual rainfall was within ±5% of the long-term station average and when the extreme value frequency curve obtained from the 20-year simulation compared reasonably well with the extreme value frequency curve obtained from the U.S. Weather Bureau Technical Paper No. 40.[4]

Runoff Module

Runoff simulation requires an estimate of the Soil Conservation Service (SCS) curve number (CN) for each study watershed. The CN values are adjusted up or down until the 10-year simulated runoff volume agrees with the measured or estimated watershed runoff volume.

Pollutant Washoff

Surface accumulation rates, pollutant decay rates, and annual pollutant yields for BOD_5, TKN, SS, and Pb were estimated for each watershed using data presented in the CSPSS User's Manual[5] or using site data. Surface accumulation rates were adjusted, when necessary, until the average annual watershed pollutant washoff from a 10-year simulation was within ±10% of the measured or estimated annual watershed pollutant washoff.

Infiltration Module

The excess infiltration module was applied only to watersheds where there was evidence that infiltration-induced overflow was a problem. When the total annual volume of infiltration-induced overflow was known, the infiltration module was calibrated to produce that overflow volume. When limited data were available, a reasonable value for excess infiltration was considered to be 5% to 10% of the annual rainfall.

Wastewater Treatment Plant Module

For the purposes of estimating Categories V and VI pollutant removal requirements, the average WWTP effluent concentrations are assumed to meet secondary effluent limits unless better effluent is known to exist at the study site.

The secondary WWTP effluent concentrations used in the 1978 Needs Survey are as follows.

BOD_5 = 30 mg/l
SS = 30 mg/l
TKN = 28 mg/l
Pb = 0.04 mg/l

Upstream Flow Module

A representative record for a 5-year period of streamflow was determined by comparing the mean annual flow during several 5-year periods to the mean annual flow for the period of record. When a representative 5-year trace was determined, the actual measured average daily flows were input to the simulation and no adjustments were necessary.

Receiving Water Module

The DO budget portion of the receiving water module can be calibrated to prototype conditions if continuous DO data at some point on the receiving stream are available.

Minimum adequate data for DO calibration are daily observations of DO for a total period of at least 2 years. From these data, an observed cumulative frequency curve of DO concentrations can be developed at a given point in the receiving water.

Continuous DO data were available to calibrate the receiving water module in Springfield, Missouri; Philadelphia, Pennsylvania; and Washington, D.C. The results of these DO calibrations are presented in Appendix A.

It was not possible to calibrate the suspended solids and dissolved lead portion of the receiving water response module due to a lack of data.

SUMMARY OF POLLUTANT REMOVAL REQUIREMENTS

The overall watershed removal requirements to meet the fish and wildlife water quality objectives presented in Chapter 2 for combined sewer system and separate sewer system study sites are presented in Tables 8-1 and 8-2, respectively. A summary of the fish and wildlife water quality objectives is presented in Table 8-3.

The results of the site study analysis indicate that higher UOD removals are required on combined systems and higher SS removals are required on separate systems. Removal requirements for dissolved lead were more dependent on the receiving water pH, hardness, and alkalinity than on storm-generated discharges. A detailed analysis of the receiving water pollutant removal requirements is presented in Chapter 10.

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1. Jordan, Jones & Goulding, Inc., and Black, Crow & Eidsness, Inc. "1976 Survey of Needs for Control of Pollution from Combined Sewer Overflows and Stormwater Discharges." EPA-430/9-76-012. MCD-48C. 10 February 1977.

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3. Edwards, M. D. "Status of the National Water Data Exchange (NAWDEX)." USGS Open File Report 76-719. Reston, Virginia. September 1976.

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5. Wycoff, R. L. and M. J. Mara. "1978 Needs Survey--Continuous Stormwater Pollution Simulation System--Users Manual" EPA-430/9-79-004. FRD-4. 10 February 1979.

Table 8-1
Overall Watershed Removal Requirements on Combined
Systems To Meet Fish and Wildlife Water Quality Objectives

Study Site	Ultimate Oxygen Demand (UOD) (percent)	Suspended Solids (SS) (percent)	Lead (Pb) (percent)	Phosphorus (P) (percent)
Rochester, NY	89	59	0	N/A
Syracuse, NY	N/A	N/A	N/A	80
Philadelphia, PA	87	75	0	N/A
Washington, DC	92	70	>100	N/A
Atlanta, GA	92	91	>100	N/A
Bucyrus, OH	83	55	0	N/A
Milwaukee, WI	93	82	0	N/A
Des Moines, IA	90	0	0	N/A
Sacramento, CA	0	54	>100	N/A
Portland, OR	18	22	>100	N/A

Notes: N/A = Not applicable
UOD = BOD + 4.57 TKN

Table 8-2
Overall Watershed Removal Requirements
On Separate Systems To Meet Fish and
Wildlife Water Quality Objectives

Study Site	Ultimate Oxygen Demand (UOD) (percent)	Suspended Solids (SS) (percent)	Lead (Pb) (percent)
Durham, NC	0	97	0
Ann Arbor, MI	0	90	0
Springfield, MO	30	41	0
Tulsa, OK	0	80	40
Castro Valley, CA	13	96	95

Note: UOD = BOD + 4.57 TKN

Table 8-3
Summary of the Fish and Wildlife Water Quality Objectives

Dissolved oxygen:

4-hour average annual minimum concentration ≥2.0 mg/l

3-day average annual minimum concentration ≥3.0 mg/l

Warm-water fish:

Average concentration ≥5.0 mg/l

Cold-water fish:

Average concentration ≥6.0 mg/l

Suspended solids:

The mean annual concentration of SS in combined sewer overflow and urban stormwater runoff shall not exceed the mean natural background SS concentration of the receiving water, with an allowable limit of at least 25 mg/l.

Dissolved lead:

96-hour maximum annual concentration ≤0.33 mg/l

Average concentration ≤0.01 mg/l (soft water)

Average concentration ≤0.025 mg/l (hard water)

Phosphorus:

(Lake sites only)

Average annual lake concentration ≤0.025 mg/l

Chapter 9
SITE STUDIES FOR ECONOMIC OPTIMIZATION OF CONTROL ALTERNATIVES

INTRODUCTION

The purpose of this chapter is to present the methodology used to establish the optimal combination of control alternatives which can achieve any desired level of pollutant removal. The optimal combination of control alternatives was determined using marginal cost analysis from economic theory.

This chapter has been divided into three major sections. The first section briefly discusses the economic theory applied. The next section presents the general methodology used on four site studies to determine the optimal combination of control alternatives which can achieve desired levels of pollutant removal. The third and final section of this chapter presents the optimal combination of control alternatives for Castro Valley, California; Bucyrus, Ohio; Des Moines, Iowa; and Milwaukee, Wisconsin. The results of these four site studies are analyzed in Chapter 10 to determine relationships between the required pollutant removal and the level of effort used with nonstructural control alternatives. In addition, a relationship was determined between the required pollutant removal and the percentage of the total removal obtained from the combined watershed and the percentage of the total removal obtained from the separate watershed when both watersheds discharge to a common receiving water.

A major portion of the material presented in this chapter was obtained from an EPA publication entitled "Stormwater Management Model: Level I--Comparative Evaluation of Storage-Treatment and Other Management Practices" by Heaney and Nix, 1977[1].

ECONOMIC THEORY

Marginal Cost Analysis

In its simplest terms, marginal may be defined as "extra." In economic terms, marginal cost is defined as the extra cost associated with an additional unit of some commodity. In economic decision making, marginal analysis determines whether an action results in a sufficient additional benefit to justify the additional cost. Marginal analysis indicates that more intensive use should be made of control alternatives with lower marginal costs, measured in dollars per pound of pollutant removed. As these activities are expanded, marginal costs increase to the point where other options become competitive.

The entire analysis can be viewed as determining, at any specified marginal cost, the quantity of pollution (or target pollutant reduction) which the various control options, in parallel, would offer to control. These results, for all control options operating in parallel, are combined to yield a composite control cost curve. The solution is guaranteed to be optimal because every option produces a diminishing marginal value of pollution control as its level of effort is expanded. For example, if streetsweeping is to be used as a control option, the initial monies will be spent where most effective, e.g., frequent sweeping on heavily loaded streets. As more money is spent, sweeping would be used on progressively cleaner streets. Thus, the pollution control effectiveness, per dollar invested, would decrease.

Production Theory

A production process seeks to increase the utility of a commodity or commodities. The relationship between the input and output of a production process is described as a production function. The shape of the production function is governed by the "law" of diminishing returns, which states that, as an input to a production process is increased with all other inputs held constant, a point will be reached beyond which any additional input will yield diminishing marginal output.

In stormwater pollution control, the production function is the mathematical relationship between the amount of pollutant removed, in pounds, and the level of effort applied. The definition of level of effort depends on the particular control measure. For example, the level of effort for streetsweeping has been defined as the fraction of days streets are swept and, for sewer flushing, it has been defined as the fraction of sewers flushed daily. The production functions used for the 1978 Needs Survey were defined and presented in Chapter 6.

SITE STUDY METHODOLOGY

In stormwater pollution control, options may operate in parallel, series, or a combination of both. A parallel operation is defined as one in which the effluent (untreated portion) of any one option does not act as the influent to any other parallel option. Streetsweeping and sewer flushing on combined sewered areas are examples of parallel operations. A serial operation is defined as one in which options are sequential with the effluent from one option acting as the influent to the next. Storage of urban runoff and treatment of the same runoff are examples of serial operations.

Parallel Operations

The logic of the marginal cost analysis procedure can be illustrated by considering the evaluation of three control options operating in parallel. The evaluation procedure is described in three steps and illustrated in Figures 9-1 and 9-2.

1. Given a production function (PF) and cost relationships for each control option, develop a total cost (TC) curve (i.e., total cost in dollars/year vs fraction of pollutant removed) for each control option (see Figure 9-1).

2. Transform each total cost (TC) curve to a marginal cost (MC) curve by graphical differentiation. The marginal cost curve defines the relationship between incremental cost of control (dollars/pound of pollutant removed) vs total amount of pollutant removed by that control technique (pounds/year).

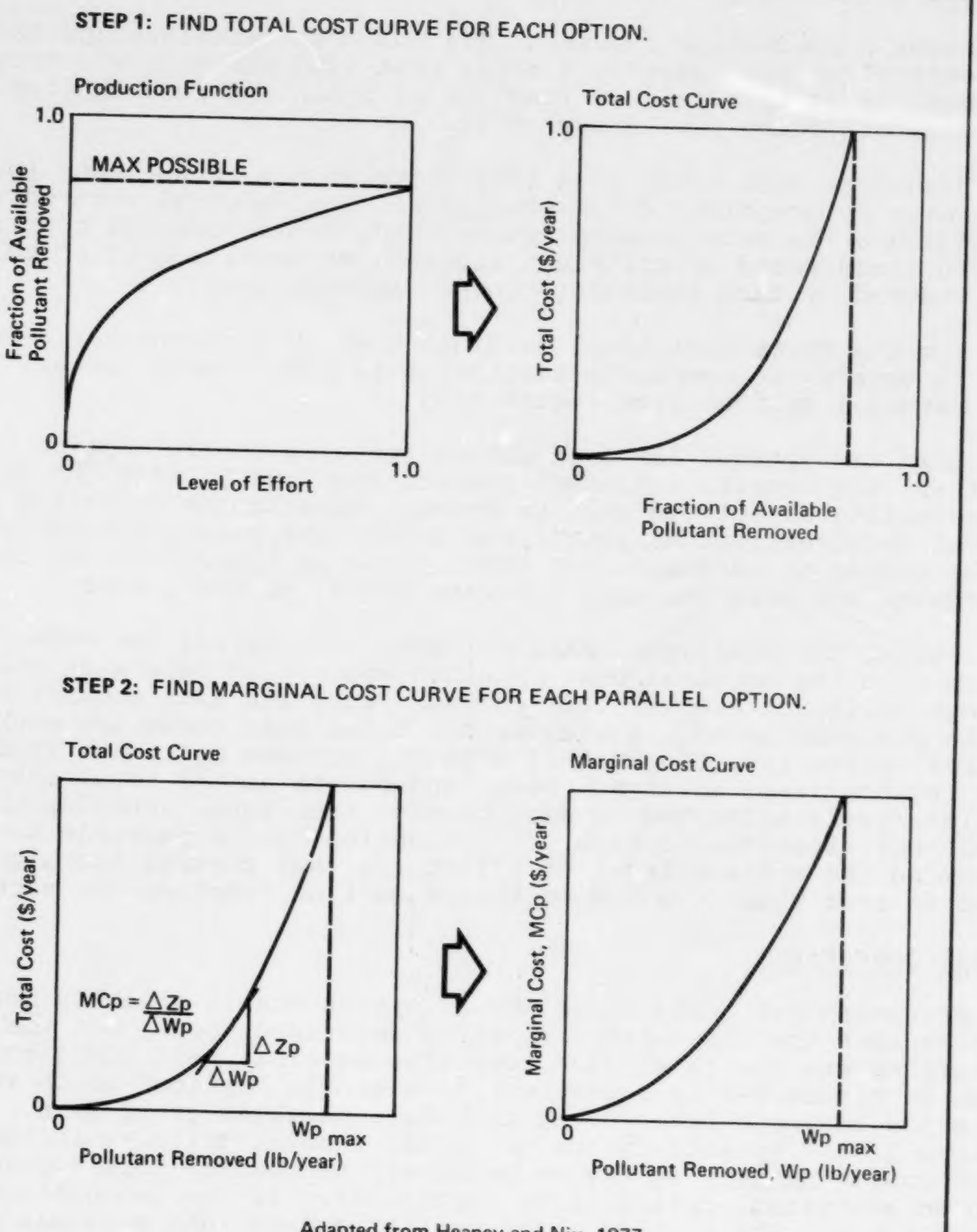
3. Sum the three individual marginal cost (MC) curves horizontally to obtain the composite marginal cost (CMC) curve for all three parallel options (see Figure 9-2).

To obtain the optimum level of effort for each control option in parallel, the overall pollutant removal required to meet the desired water quality objectives must be known. Knowing the overall pollutant removal required (pounds/year), one enters the x-axis (pounds/year) of the composite marginal cost (CMC) curve in Figure 9-2 and finds the equivalent marginal cost (dollars/pound) on the y-axis.

Next, enter the individual marginal cost (MC) curves for each control option with the marginal cost obtained above, and determine the optimum pollutant removal rate (pounds/year) for each control option in the mix considered. Now enter the total cost curve for each control option (see Figure 9-1) with the optimum pollutant removal rate (pounds/year) obtained above, and determine the total cost (dollars/year) allocated to each control technique. Knowing the total cost allocated to each control option, it is possible to determine the optimum level of effort for that control technique, based on cost equations and on the production function for each option.

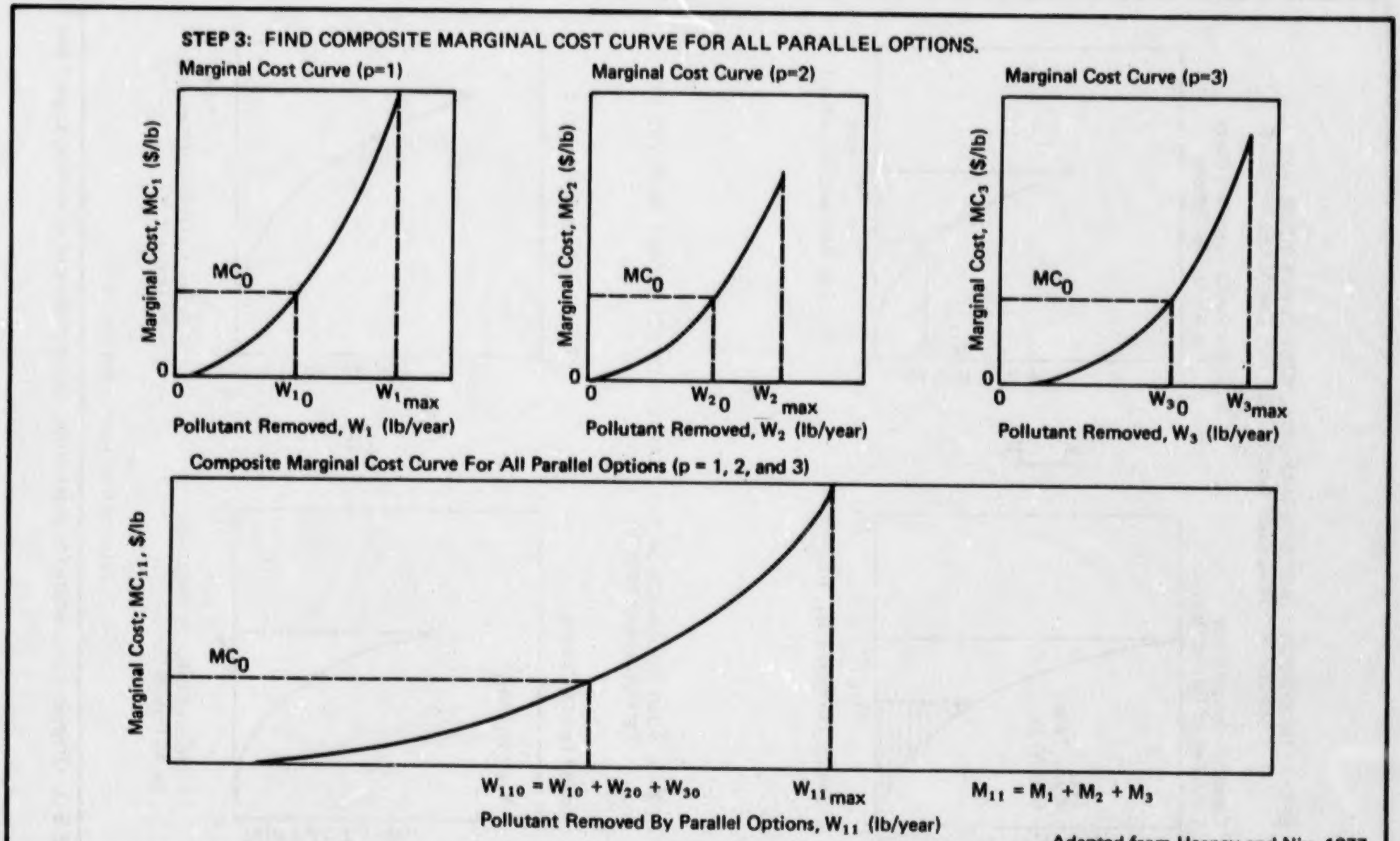
Serial Operations

The procedure for analysis of serial operations is slightly more complex than the three-step operation described above, but the principles are the same. The composite marginal cost (CMC) curve shown in Figure 9-2 is equivalent to a single "option" which represents the economic behavior of the whole parallel group (i.e., options 1-3). To satisfy the pollutant removal criteria in the least costly manner, it may be necessary to combine this "option" with an additional option (i.e., option 4). If the two options act in series, the procedure for combining them into a single equivalent "option" is continued from the previous Step 3 and illustrated in Figures 9-3 and 9-4 as follows.



Adapted from Heaney and Nix, 1977

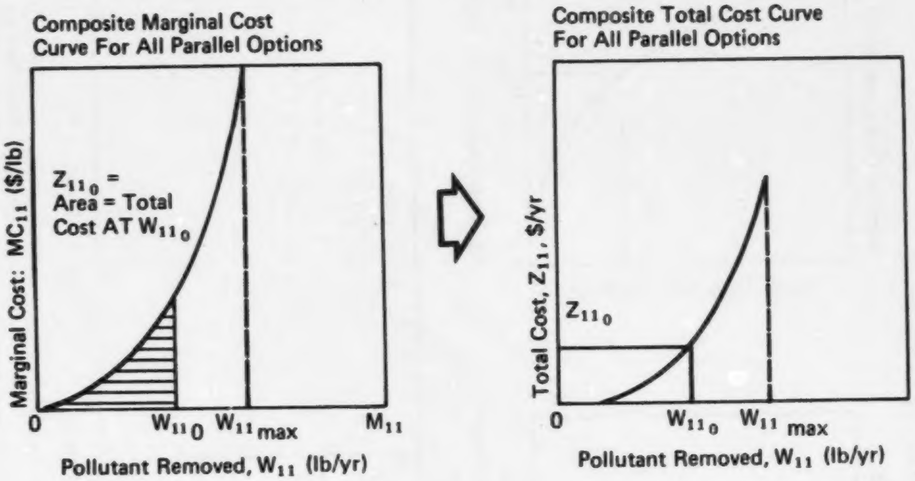
FIGURE 9-1. Graphical procedure for determining optimal control strategies, steps 1 and 2.



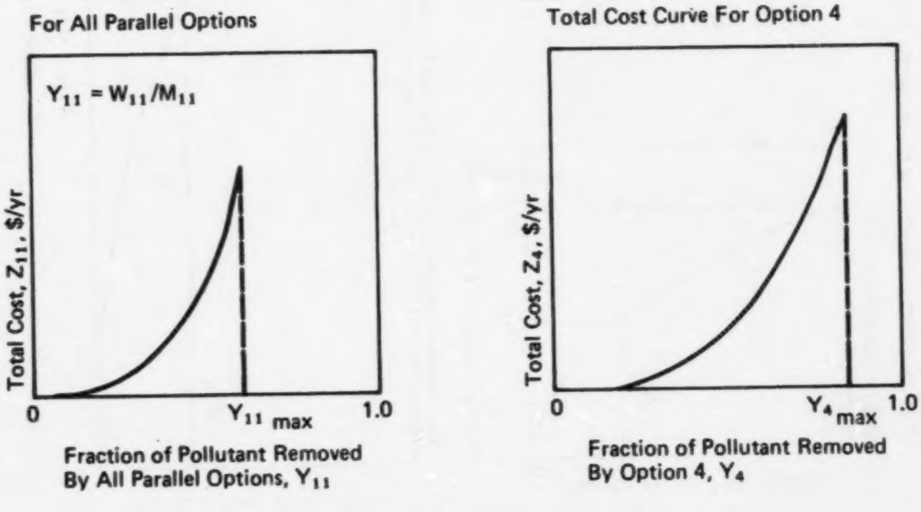
Adapted from Heaney and Nix, 1977

FIGURE 9-2. Graphical procedure for determining optimal control strategies, step 3.

STEP 4: INTEGRATE COMPOSITE MARGINAL COST CURVE TO OBTAIN COMPOSITE TOTAL COST CURVE FOR ALL PARALLEL OPTIONS.

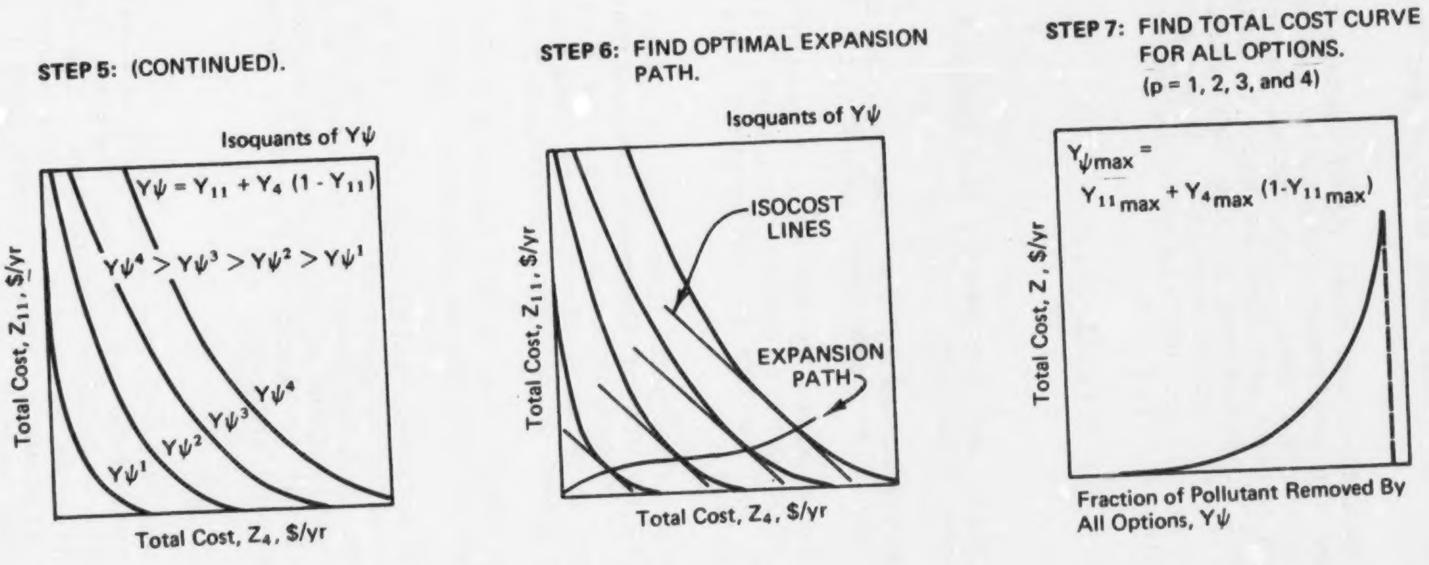


STEP 5: FIND ISOQUANTS OF THE FRACTION OF POLLUTANT REMOVED BY OPTIONS IN SERIES, Y.



Adapted from Heaney and Nix, 1977

FIGURE 9-3. Graphical procedure for determining optimal control strategies, steps 4 and 5.



Adapted From Heaney and Nix 1977.

FIGURE 9-4. Graphical procedure for determining optimal control strategies, steps 6 and 7.

4. Integrate the composite marginal cost (CMC) curve (see Step 3-parallel operations) to obtain the composite total cost (CTC) curve (See Figure 9-3). This step must be performed for each serial operation.

5. Transform the composite total cost (CTC) curves to fractional values by dividing the pollutant removed by the annual pollutant discharged from that watershed. Fractional values of the two control options in series can then be used to calculate all possible total cost combinations of the two inputs which obtain a constant output of pollutant removal. These constant removal curves are called isoquants and are calculated from the following equation. (See Figure 9-4.)

$$Y\psi = Y_{11} + Y_4\ (1-Y_{11}) \qquad (9\text{-}1)$$

where

$Y\psi$ = Total pollutant removed by two control alternatives in series, fraction.

Y_{11} = Pollutant removed by the first serial control option (e.g., parallel management practices), fraction.

Y_4 = Pollutant removed by the second serial option (e.g., storage/treatment), fraction. (In this example, S/T is the fourth control alternative considered.)

6. Find the optimal expansion path from the isoquants (see Figure 9-4) by constructing points of tangency between the isoquants and isocost lines. Isocost lines are lines of equal cost. These tangent points determine the optimal combination of each option to obtain a given quantity of pollutant removed.

7. Find the fractional total cost (FTC) curve for the optimal combination of both serial options as shown on Figure 9-4.

Having established the fractional total cost (FTC) curve in Step 7, the optimal operating level of stormwater pollution control options, in parallel and in series, can be found if the required pollutant removal is known. The combination of watershed management practices and washoff storage/treatment is found by following these seven steps in reverse (i.e., Figures 9-4 through 9-1).

Selected Economic Study Sites

This economic technique was used to determine the optimal combination of control alternatives needed to achieve any desired level of BOD_5 or SS removal from three basic watershed categories. The three watershed categories are: (1) watersheds with only combined sewer overflow (CSO), (2) watersheds with only stormwater runoff (SWR), and (3) watersheds with both CSO and SWR. The four study sites selected to represent these watershed categories are: (1) Castro Valley, California (SWR only), (2) Bucyrus, Ohio (CSO only), (3) Des Moines, Iowa (both CSO and SWR), and (4) Milwaukee, Wisconsin (both CSO and SWR).

Both nonstructural and structural control options were evaluated at each site. Streetsweeping, sewer flushing and storage/treatment were analyzed on CSO watersheds and streetsweeping and storage/ treatment on SWR watersheds.

CSO Watersheds

A schematic of the graphical procedure utilized to obtain the optimal control strategy for pollutant removal from a CSO watershed is shown in Figure 9-5. The total cost (TC) curves for streetsweeping (SW) and sewer flushing (SF) were calculated using the production functions presented in Figures 6-3 and 6-4, pollutant removal equations 6-7 and 6-8, and the following total cost equations.

$$TC_{SW} = (X_{SW})\ (WD)\ (CM)\ (C_{SW}) \qquad (9\text{-}2)$$

and

$$TC_{SF} = (X_{SF})\ (DA)\ (C_{SF}) \qquad (9\text{-}3)$$

where

TC_{SW} = Total annual cost of streetsweeping, \$/year.

X_{SW} = Fraction of streets swept daily, from Figure 6-3.

WD = Working days per year available to sweep the streets.

CM = Curb-miles available to sweep per day.

C_{SW} = Average cost to sweep 1 curb-mile of street. A value of \$10/curb-mile was used, in all computations.

TC_{SF} = Total annual cost of sewer flushing, \$/year.

X_{SF} = Fraction of sewers flushed daily.

DA = Drainage area, acres.

C_{SF} = Average annual cost to flush all sewers daily. A value of \$1,284/acre-year was used, in all computations.

The total cost curves (TC) calculated from application of these equations and the production functions are then differentiated, and the marginal cost (MC) curves are obtained. The two nonstructural controls are combined into a single nonstructural (NS) option through a parallel operation. The resulting composite marginal cost (CMC) curve is integrated to obtain the composite total cost (CTC) curve for this single nonstructural option. The composite total cost (CTC)

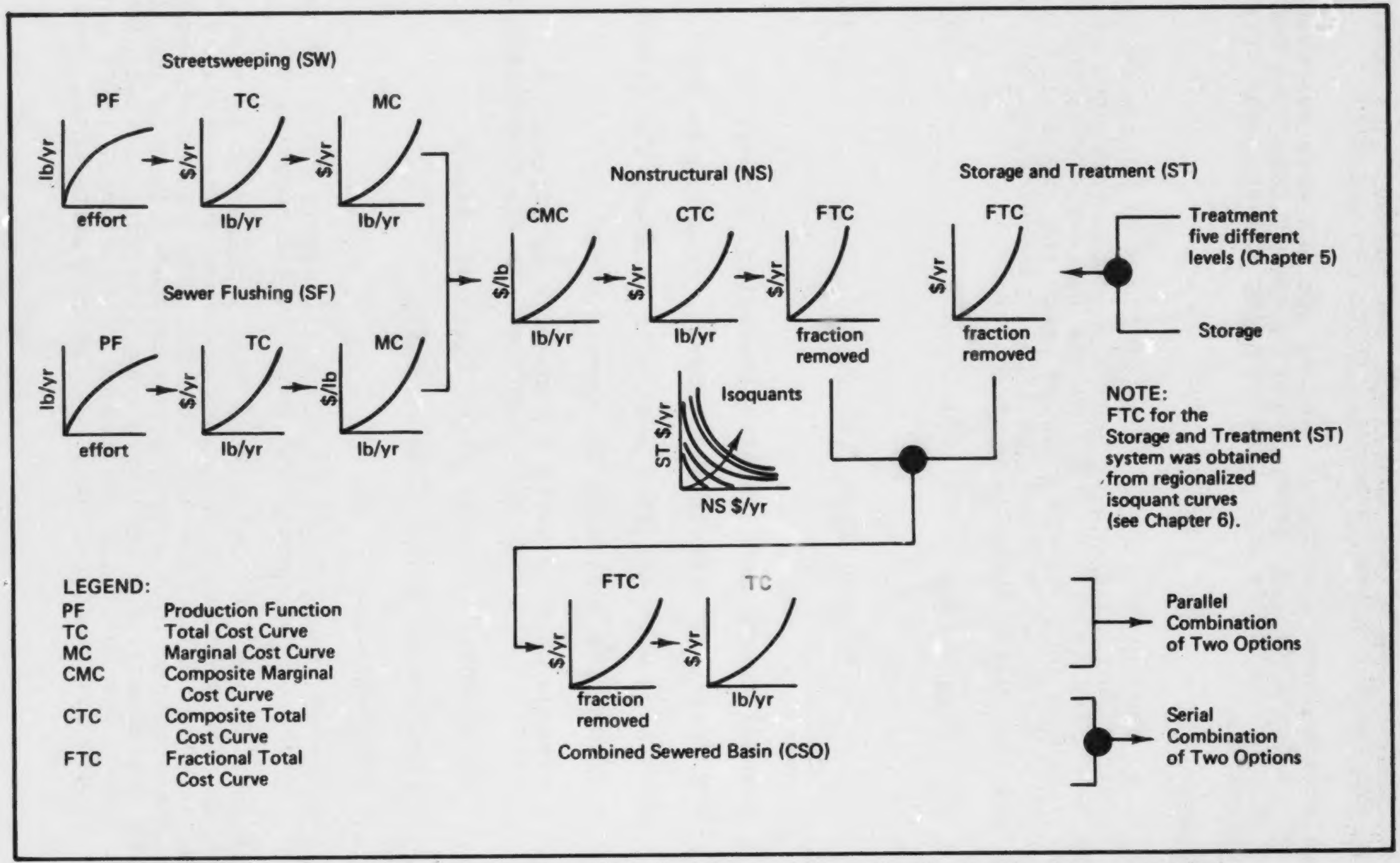

Streetsweeping (SW)
PF
lb/yr
effort
TC
$/yr
lb/yr
MC
$/yr
lb/yr
Sewer Flushing (SF)
PF
lb/yr
effort
TC
$/yr
lb/yr
MC
$/lb
lb/yr
Nonstructural (NS)
CMC
$/lb
lb/yr
CTC
$/yr
lb/yr
FTC
$/yr
fraction removed
Storage and Treatment (ST)
FTC
$/yr
fraction removed
Treatment five different levels (Chapter 5)
Storage
Isoquants
ST $/yr
NS $/yr
NOTE: FTC for the Storage and Treatment (ST) system was obtained from regionalized isoquant curves (see Chapter 6).
FTC
$/yr
fraction removed
TC
$/yr
lb/yr
Combined Sewered Basin (CSO)
LEGEND:
PF Production Function
TC Total Cost Curve
MC Marginal Cost Curve
CMC Composite Marginal Cost Curve
CTC Composite Total Cost Curve
FTC Fractional Total Cost Curve
Parallel Combination of Two Options
Serial Combination of Two Options

FIGURE 9-5. Schematic for the economic optimization of control alternatives for combined sewer watersheds.

curve for the NS option is transformed to a fractional total cost (FTC) curve by dividing the pollutant removed by the annual pollutant discharge from the entire CSO watershed.

The fractional total cost (FTC) curve for the single structural option of storage-treatment (ST) was obtained from the regionalized isoquants described in Chapter 6. The single storage-treatment (ST) option shown on Figure 9-5 (and later on Figure 9-6) is the least cost combination of each of the five different treatment levels described earlier in Chapter 5.

A serial operation is then used to convert both the nonstructural (NS) option and the storage-treatment (ST) option into a single fractional total cost (FTC) curve for all of the control alternatives on the CSO watershed. The total annual pollutant discharge from the CSO watershed is used to transform the fractional total cost (FTC) curve to a simple total cost (TC) curve.

This last total cost (TC) curve represents the optimum combination of dollars spent and pollutant removed throughout the entire CSO basin. To achieve a specified pollutant removal in pounds per year or a fraction thereof, one proceeds in reverse through the curves shown on Figure 9-5 and determines the optimal costs and operating levels of each control option in the mixture. These optimal cost and operating levels defined the least-costly control strategy which can achieve the desired pollutant removal from the CSO watershed.

SWR Watersheds

A schematic of the graphical procedure utilized to obtain the optimal control strategy for pollutant removal from a SWR watershed is shown in Figure 9-6. Streetsweeping is the only nonstructural control alternative evaluated on SWR watersheds.

Once again, a serial operation is used to convert both the streetsweeping (SW) option and the storage-treatment (ST) option into a single fractional total cost (FTC) curve for all the control alternatives on the SWR watershed. The total annual pollutant discharge throughout the SWR watershed is used to transform the FTC curve to a simple total cost (TC) curve.

This last total cost (TC) curve, shown on Figure 9-6, represents the optimum combination of dollars spent and pollutant removed throughout the entire SWR basin. By progressing backwards through the curves, one can obtain the optimal control strategies geared toward specific pollutant removals from the SWR watershed.

CSO and SWR Watersheds Combined

As one might expect, the determination of optimal control strategies on watersheds that contain both CSO and SWR components is somewhat more complicated. A schematic of the additional steps needed to obtain the optimal control strategies on CSO and SWR watersheds

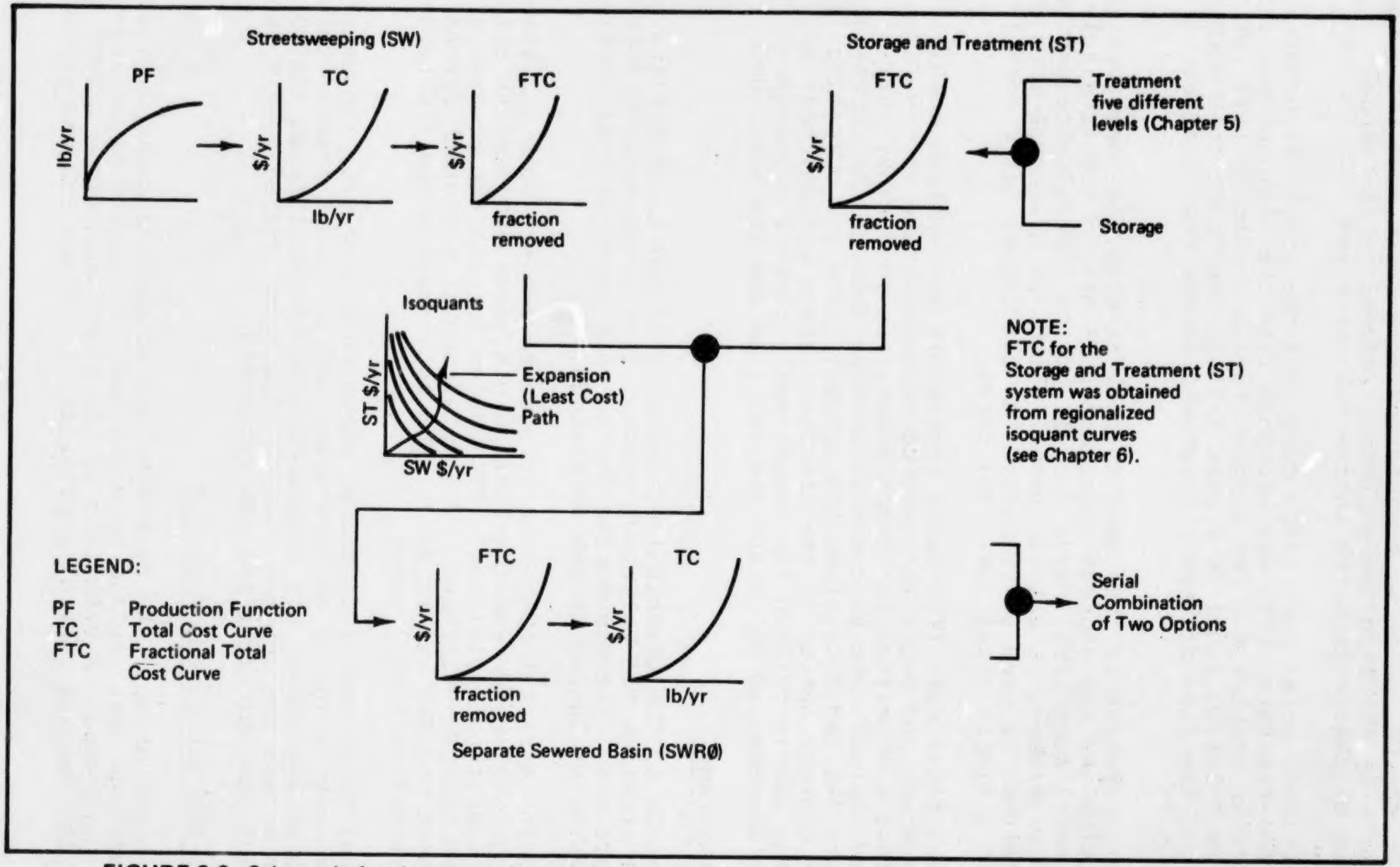

Streetsweeping (SW)
PF
lb/yr
TC
$/yr
lb/yr
FTC
$/yr
fraction removed
Storage and Treatment (ST)
FTC
$/yr
fraction removed
Treatment five different levels (Chapter 5)
Storage
Isoquants
ST $/yr
SW $/yr
Expansion (Least Cost) Path
NOTE: FTC for the Storage and Treatment (ST) system was obtained from regionalized isoquant curves (see Chapter 6).
LEGEND:
PF Production Function
TC Total Cost Curve
FTC Fractional Total Cost Curve
FTC
$/yr
fraction removed
TC
$/yr
lb/yr
Separate Sewered Basin (SWR0)
Serial Combination of Two Options

FIGURE 9-6. Schematic for the economic optimization of control alternatives for urban stormwater (separate sewer).

together is presented in Figure 9-7. Starting with the last total cost (TC) curves obtained from Figures 9-5 and 9-6, the marginal cost (MC) curves are computed for the CSO watershed and the SWR watershed, respectively.

The CSO and SWR marginal cost curves are then added in parallel to obtain the total composite marginal cost (TCMC) curve of the watersheds together. The (TCMC) curve is then integrated to obtain the total composite total cost (TCTC) curve for the entire basin. This TCTC curve represents the least cost combination of seven control alternatives (five storage/treatment levels and two management practices) on two watersheds to obtain any desired removal of pollutants. The TCTC can easily be converted into a total fractional total cost (TFTC) curve by dividing the horizontal axis by the annual pollutant discharge from the CSO and SWR basins together.

To find the optimal control strategy for an entire basin (CSO and SWR together), one starts with a desired pollutant removal in pounds per year or a fraction thereof and proceeds in reverse through the curves on Figures 9-7, 9-6, and 9-5 to determine the optimal costs and operating levels of the seven control alternatives on the two watersheds.

SITE STUDY RESULTS

Site study data input to the economic procedure described above is presented in Table 9-1. Streetsweeping working days per year are based on 6 working days per week for 52 weeks, 8 holidays, and 60 days of snowcover in areas with snow. The total curb-miles available to sweep were estimated from Figure G-2 in the EPA Areawide Assessment Procedures Manual, Volume III[2]. Finally, the number of treatment plants were calculated with the following equation, which was utilized in the 1976 Needs Survey to estimate the number of treatment plants as a function of area served.

$$NTP = \left(\frac{DA}{1,000}\right)^{0.435} \qquad (9\text{-}4)$$

where

NTP = Number of treatment plants per watershed.

DA = Drainage area of the watershed, acres.

The total watershed discharges, drainage areas, and population densities were taken from the site study data presented in Appendix A.

A comparison of the unit costs at each of the four site studies is shown in Figures 9-8 and 9-9 for BOD_5 and SS, respectively. The wide range in unit removal costs at the four sites are indicators of the wide range of watershed pollutant yields (e.g., the CSO discharge of BOD_5 from Milwaukee is 318.97 lb/acre-year while

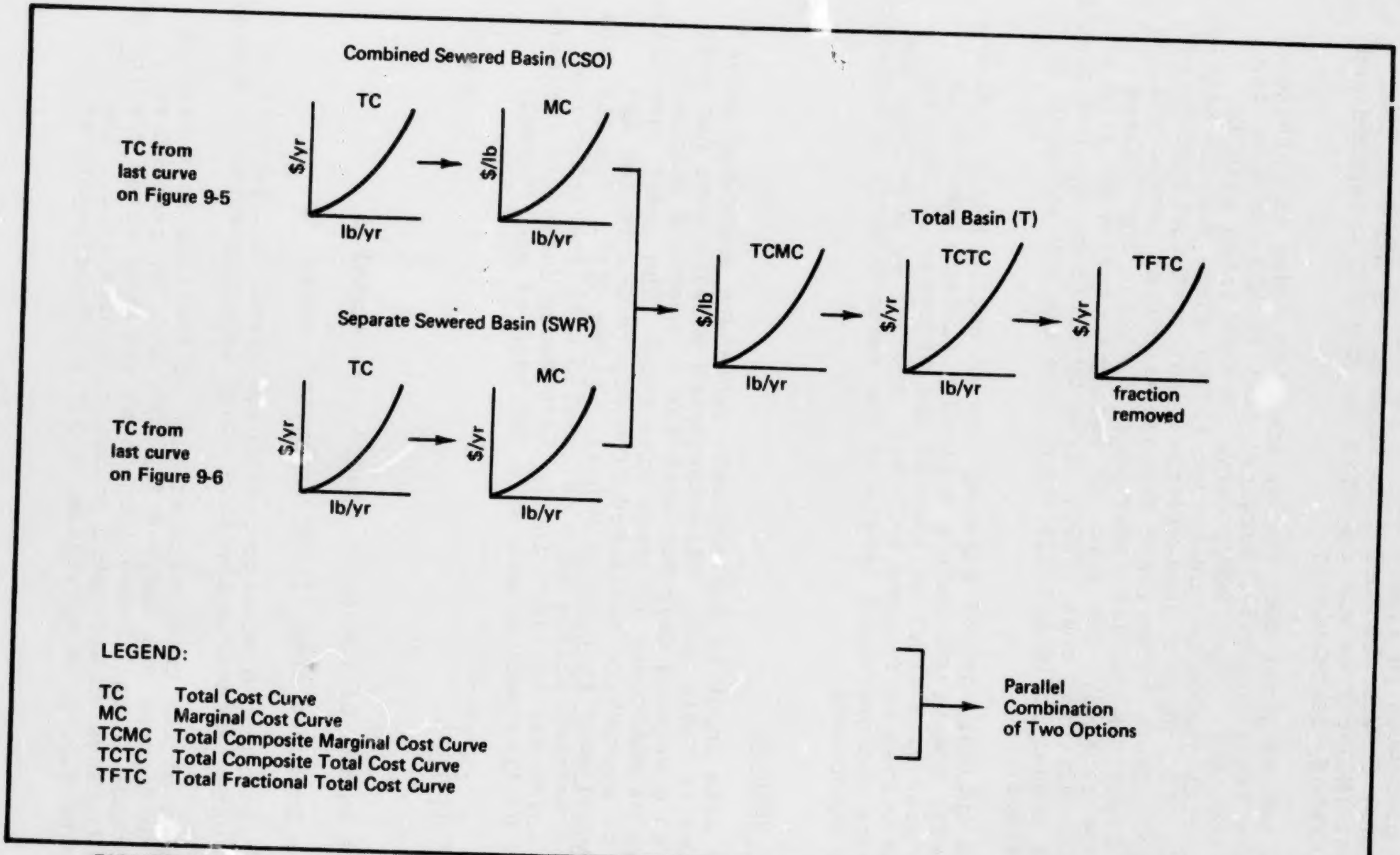


FIGURE 9-7. Schematic for the economic optimization of control alternatives for urban areas served by both combined and separate sewer systems.

Table 9-1
Site Study Input Data For Economic
Optimization of Wet-Weather Pollution Control

Study Watershed	Streetsweeping[a] F_{SW} Φ_{SW}	Total Watershed Discharge (lb/yr)		Streetsweeping Working Days Per Year	Curb-Miles	Number of Treatment Plants	Area (acres)	Population Density (persons/acre)
		BOD_5	SS					
Castro Valley Separate	0.30	291,000	4,766,667	304	43	2	3,850	8.00
Bucyrus Combined	0.15	233,705	3,690,000	244	55	2	2,559	6.00
Milwaukee Combined	0.11	1,850,000	4,940,000	244	355	2	5,800	27.3
Milwaukee Separate	0.32	600,000	9,840,000	244	108	4	27,400	3.6
Des Moines Combined	0.15	109,300	444,400	244	85	2	4,018	8.33
Des Moines Separate	0.30	752,100	5,828,000	244	240	5	45,000	7.82

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[a] See Equation 6-6 for definition of F_{sw} and ϕ_{sw}.

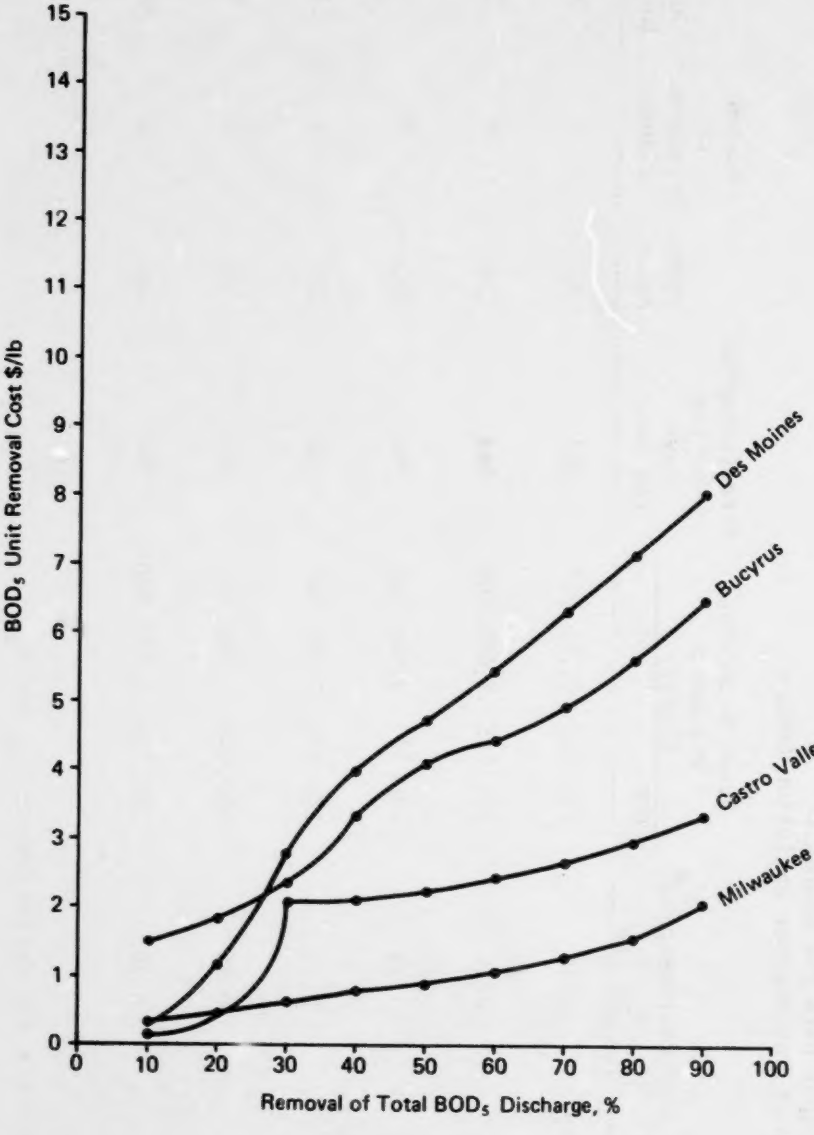


FIGURE 9-8. Unit costs for the optimized removal of BOD$_5$ discharges.

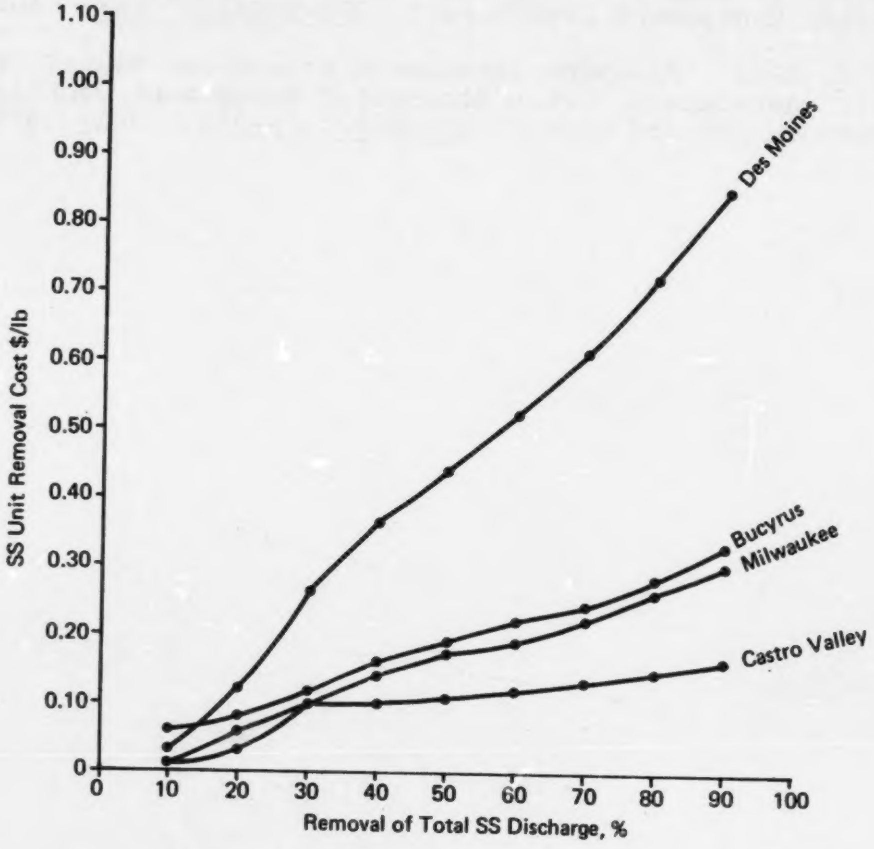


FIGURE 9-9. Unit costs for the optimized removal of SS discharges.

only 27.20 lb/acre-year at Des Moines). In addition, there is a distinct change in curve shape at about 30% to 40% removal for each of the study sites. This break in the unit cost curve indicates the shift from using all nonstructural controls to a mix of nonstructural and storage/treatment controls. Castro Valley, California, shows the sharpest break in the unit cost curve because the high operation and maintenance costs of storage/treatment at low removals means that storage/treatment is not used unless greater than 30% removal of the pollutant discharge is desired.

A complete tabulation of the optimum total costs and pollutant removals by watershed and control option is presented in Tables 9-2 through 9-9.

REFERENCES

1. Heaney, J. P., and S. J. Nix. "Stormwater Management Model: Level I--Comparative Evaluation of Storage/Treatment and Other Management Practices." EPA-600/2-77-083. April 1977.

2. U.S. EPA. "Areawide Assessment Procedures Manual, Volume III, Appendix G, Urban Stormwater Management Techniques: Performance and Cost." EPA-600/9-76-014. July 1976.

Table 9-2
Optimum Combination of Control
Alternatives for Castro Valley BOD_5

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Separate Watershed Removals		
		SW (%)	S/T (%)	Total Watershed (%)
10	$ 4,759	10.0	0	10
20	27,337	20.0	0	20
30	177,582	19.6	12.9	30
40	247,277	19.6	25.4	40
50	329,129	19.6	37.8	50
60	426,606	19.4	50.4	60
70	544,577	19.2	62.9	70
80	689,988	18.5	75.5	80
90	872,418	16.7	88.0	90

Note: SWR watershed BOD_5 discharge = 75.6 lb/acre/year.
SW = percent removed by street sweeping.
S/T = percent removed by storage treatment.

Table 9-3
Optimum Combination of Control
Alternatives for Castro Valley Suspended Solids

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Separate Watershed Removals		
		SW (%)	S/T (%)	Total Watershed (%)
10	$ 4,759	10.0	0	10
20	27,337	20.0	0	20
30	142,573	18.9	13.7	30
40	197,636	18.9	26.1	40
50	262,678	18.8	38.4	50
60	340,671	18.7	50.8	60
70	435,853	18.4	63.2	70
80	554,383	17.8	75.7	80
90	704,958	15.8	88.1	90

Note: SWR watershed SS discharge = 1,238.1 lb/acre/year.
SW = percent removed by streetsweeping.
S/T = percent removed by storage/treatment.

Table 9-4
Optimum Combination of Control Alternatives For Bucyrus BOD_5

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Combined Watershed Removals			
		SW (%)	SF (%)	S/T (%)	Total Watershed (%)
10	$ 34,963	8.2	4.3	0	12.5
20	85,586	9.1	11.0	0	20.1
30	165,430	9.8	20.2	0	30.0
40	310,057	10.6	29.4	0	40.0
50	475,960	9.7	18.4	31.0	50.4
60	621,720	9.7	18.5	44.7	60.3
70	806,905	9.5	16.7	59.0	69.7
80	1,047,950	9.3	10.8	74.0	79.2
90	1,356,880	8.7	0	89.5	90.4

Note: CSO watershed BOD_5 discharge = 91.3 lb/acre/year.
SW = percent removed by streetsweeping.
SF = percent removed by sewer flushing.
S/T = percent removed by storage/treatment.

Table 9-5
Optimum Combination of Control
Alternatives for Bucyrus Suspended Solids

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Combined Watershed Removals			
		SW (%)	SF (%)	S/T (%)	Total Watershed (%)
10	$ 23,535	7.6	0	0	7.6
20	58,685	9.0	10.3	0	19.3
30	116,862	9.8	19.8	0	29.6
40	231,722	10.6	29.4	0	40.0
50	355,316	9.8	19.8	37.9	56.3
60	476,314	9.8	20.4	42.8	60.1
70	631,382	9.7	19.3	67.5	76.9
80	836,230	9.6	17.4	72.5	79.9
90	1,109,074	8.5	4.8	88.1	89.7

Note: CSO watershed SS discharge = 1,441.97 lb/acre/year.
SW = percent removed by streetsweeping.
SF = percent removed by sewer flushing.
S/T = percent removed by storage/treatment.

Table 9-6
Optimum Combination of Control
Alternatives for Des Moines BOD_5

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Total Areawide Removals		Calculated Combined Watershed Removals				Calculated Separate Watershed Removals		
		CSO Watershed (%)	SWR Watershed (%)	SW (%)	SF (%)	S/T (%)	Total Watershed (%)	SW (%)	S/T (%)	Total Watershed (%)
10	$ 24,000	0	9.5	0	0	0	0	10.9	0	10.9
20	192,000	2.0	17.9	8.7	7.0	0	15.7	20.5	0	20.5
30	720,000	2.6	27.2	9.1	11.5	0	20.6	21.0	12.8	31.1
40	1,344,000	2.9	37.3	9.3	13.9	0	23.2	20.9	27.5	42.7
50	2,032,000	3.2	47.7	9.5	16.0	0	25.5	20.7	42.8	54.6
60	2,840,000	3.5	57.6	9.7	18.2	0	27.9	20.4	57.3	66.0
70	3,808,000	3.8	66.8	9.8	20.1	0	29.9	19.9	70.6	76.5
80	4,912,000	4.1	75.9	10.0	22.1	0	32.1	18.8	83.9	86.9
90	6,208,000	7.3	85.8	8.8	7.9	48.8	57.4	13.9	98.0	98.3

Notes: CSO watershed BOD_5 discharge = 27.20 lb/acre/year.
SWR watershed BOD_5 discharge = 16.71 lb/acre/year.
SW = percent removed by streetsweeping
SF = percent removed by sewer flushing.
S/T = percent removed by storage/treatment.

Table 9-7
Optimum Combination of Control
Alternatives for Des Moines Suspended Solids

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Total Areawide Removals		Calculated Combined Watershed Removals				Calculated Separate Watershed Removals		
		CSO Watershed (%)	SWR Watershed (%)	SW (%)	SF (%)	S/T (%)	Total Watershed (%)	SW (%)	S/T (%)	Total Watershed (%)
10	$ 18,000	0	8.4	0	0	0	0	9.0	0	9.0
20	150,000	0	18.6	0	0	0	0	20.0	1.0	20.8
30	495,000	0	29.9	0	0	0	0	20.0	15.2	32.2
40	900,000	0	40.3	0	0	0	0	20.0	29.2	43.4
50	1,385,000	0	50.2	0	0	0	0	20.0	42.5	54.0
60	1,965,000	0	59.6	0	0	0	0	19.8	55.2	64.1
70	2,700,000	0.5	70.1	7.6	0	0	7.6	19.4	69.5	75.4
80	3,620,000	0.6	79.7	8.2	0.8	0	9.0	18.4	82.6	85.8
90	4,800,000	1.1	89.3	8.8	7.6	0	16.4	13.9	95.5	96.1

Notes: CSO watershed SS discharge = 110.6 lb/acre/year.
SWR watershed SS discharge = 129.5 lb/acre/year.
SW = percent removed by streetsweeping.
SF = percent removed by sewer flushing.
S/T = percent removed by storage/treatment.

Table 9-8
Optimum Combination of Control
Alternatives for Milwaukee BOD_5

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Total Areawide Removals		Calculated Combined Watershed Removals				Calculated Separate Watershed Removals		
		CSO Watershed (%)	SWR Watershed (%)	SW (%)	SF (%)	S/T (%)	Total Watershed (%)	SW (%)	S/T (%)	Total Watershed (%)
10	$ 78,000	1.7	3.5	2.2	0	0	2.2	14.1	0	14.1
20	240,000	15.2	4.5	4.7	15.4	0	20.1	18.5	0	18.5
30	480,000	25.3	4.8	6.1	27.4	0	33.5	19.8	0	19.8
40	750,000	34.9	5.0	4.6	14.7	33.3	46.2	20.5	0	20.5
50	1,092,000	44.9	5.1	4.6	14.7	49.7	59.4	20.9	0	20.9
60	1,560,000	54.1	5.4	4.4	12.4	66.0	71.7	22.0	0	22.0
70	2,208,000	64.8	5.6	0	0	85.8	85.8	22.7	0	22.7
80	3,060,000	72.9	7.1	0	0	96.6	96.6	23.0	7.9	29.1
90	4,440,000	72.9	17.1	0	0	96.6	96.6	22.2	61.2	69.8

Notes: CSO watershed BOD_5 discharge = 319.0 lb/acre/year.
SWR watershed BOD_5 discharge = 21.9 lb/acre/year.
SW = percent removed by streetsweeping.
SF = percent removed by sewer flushing.
S/T = percent removed by storage/treatment.

Table 9-9
Optimum Combination of Control
Alternatives for Milwaukee Suspended Solids

Desired Total Basin Removal (%)	Total Cost (dollars/yr)	Calculated Total Areawide Removals		Calculated Combined Watershed Removals				Calculated Separate Watershed Removals		
		CSO Watershed (%)	SWR Watershed (%)	SW (%)	SF (%)	S/T (%)	Total Watershed (%)	SW (%)	S/T (%)	Total Watershed (%)
10	$ 15,000	0	8.1	0	0	0	0	12.1	0	12.1
20	175,000	0.8	17.0	2.4	0	0	2.4	22.0	4.6	25.6
30	455,000	2.2	26.5	3.3	3.4	0	6.7	22.1	22.7	39.8
40	800,000	6.1	34.5	4.5	13.8	0	18.3	22.0	38.2	51.8
50	1,225,000	8.8	39.5	5.4	20.9	0	26.3	22.0	47.9	59.4
60	1,710,000	15.5	45.4	4.6	14.3	33.8	46.3	21.8	59.3	68.2
70	2,310,000	19.1	51.9	4.7	14.8	46.8	57.2	21.4	72.0	78.0
80	3,065,000	22.2	58.3	4.5	13.8	59.0	66.5	20.4	84.3	87.5
90	4,050,000	24.8	64.5	3.9	8.7	70.4	74.1	15.8	96.3	96.9

Notes: CSO watershed SS discharge = 851.7 lb/acre/year.
SWR watershed SS discharge = 359.1 lb/acre/year.
SW = percent removed by streetsweeping.
SF = percent removed by sewer flushing.
S/T = percent removed by storage/treatment.

Chapter 10
ANALYSIS OF SITE STUDY RESULTS

The 15 site investigations resulted in the development of a considerable volume of site-specific data related to hydrology, waste loadings, required stormwater and combined sewer overflow treatment, and economic optimization. This chapter analyzes these data and develops appropriate conclusions and generalizations which can be applied nationwide for estimating national needs.

POLLUTANT REMOVAL REQUIREMENTS

Pollutant removal requirements were determined for the four indicator pollutants, suspended solids, ultimate oxygen demand, dissolved lead, and phosphorus, at each study site where the indicator pollutant was applicable. The analysis of these results are presented, by pollutant, in the following subsections.

Suspended Solids (SS)

Suspended solids removal requirements to meet the fish and wildlife water quality objective were estimated at nine of the 10 combined sewer study sites. Only one combined sewer site did not require some suspended solids removal to meet the selected criteria. Suspended solids removal requirements for combined sewer sites ranged from 0% to 91% and averaged 56%.

Each of the five urban stormwater runoff sites required removal of suspended solids to meet the fish and wildlife water quality objective. Removal requirements ranged from 41% to 97% and averaged 81%. Determination of suspended solids removal requirements for a given urban runoff quality and receiving water quality is computed as follows.

$$\mathrm{SSREM} = \frac{\mathrm{SS} - \mathrm{SSA}}{\mathrm{SS}} \times 100 \qquad (10\text{-}1)$$

where

SSREM = Suspended solids removal requirement, in percent.

SS = Average areawide concentration of suspended solids in urban runoff and/or combined sewer overflow, in mg/l.

SSA = Allowable concentration of suspended solids in urban runoff or combined sewer overflow, in mg/l.

The allowable concentration, SSA, is equal to the mean receiving water background concentration or 25 mg/l, whichever is larger.

Ultimate Oxygen Demand (UOD)

Ultimate oxygen demand removal requirements to meet the dissolved oxygen criteria of the fish and wildlife water quality objective were estimated for nine of the 10 combined sewer study sites. Only one combined sewer study site (Sacramento, California) did not require UOD removal to meet the selected criteria. Several of the study sites, most notably Milwaukee, Wisconsin, and Philadelphia, Pennsylvania, could not meet the selected dissolved oxygen receiving water quality criteria even if all oxygen-demanding pollutants were removed from urban stormwater runoff and combined sewer overflow. In these cases, UOD removal requirements were determined based on the elimination of 90% of the low DO events which could be eliminated by control of pollutants from SWR and CSO. Ultimate oxygen demand removal requirements for combined sewer sites ranged from 0% to 93% and averaged 72%.

Only two of the five urban stormwater runoff sites required removal of oxygen-demanding materials to meet the selected dissolved oxygen receiving water criteria. UOD removal requirements for urban stormwater runoff ranged from 0% to 30% and averaged only 9%.

Development of a relationship between low dissolved oxygen occurrences and urban area/receiving water characteristics based on results of the continuous simulation was one of the main objectives of the site studies. After preliminary correlation analysis of study site characteristics and resulting total annual duration of low DO values (i.e., <2.0 mg/l), it was reasoned that low DO resulted from two different types of critical events. These are dry-weather events and wet-weather events. Thus, two areawide quality parameters, the wet-weather quality parameters (WWQP) and the dry-weather quality parameter (DWQP), were defined. These parameters are in turn a function of the waste loads and flows occurring during each type of event.

The wet-weather quality parameter and dry-weather quality parameter are defined as follows.

$$\mathrm{WWQP} = \frac{\mathrm{CSOQP} + \mathrm{SWRQP} + \mathrm{USFQP} + \mathrm{WWTPQP}}{\mathrm{QWW} * K_2} \qquad (10\text{-}2)$$

and

$$\mathrm{DWQP} = \frac{\mathrm{USFQP} + \mathrm{WWTPQP}}{\mathrm{QDW} * K_2} \qquad (10\text{-}3)$$

where

CSOQP = Combined sewer overflow quality parameter.

SWRQP = Urban stormwater runoff quality parameter.

USFQP = Upstream flow quality parameter.

WWTPQP = Wastewater treatment plant quality parameter.

QWW = Mean receiving water flow occurring during wet-weather, in cfs.

QDW = Mean receiving water flow occurring during dry-weather, in cfs.

K_2 = Receiving water reaeration rate, in 1/day (base e).

The individual areawide waste source quality parameters are defined by the following equations.

$$CSOQP = \frac{LCSO * K_{11}}{D_1 * 8,760} \qquad (10\text{-}4)$$

$$SWRQP = \frac{LSWR * K_{12}}{D_2 * 8,760} \qquad (10\text{-}5)$$

$$USFQP = \frac{LUSF * K_{13}}{8,760} \qquad (10\text{-}6)$$

$$WWTPQP = \frac{LWWTP * K_{14}}{8,760} \qquad (10\text{-}7)$$

where

LCSO = Total annual BOD_5 load from combined sewer overflow, in pounds per year.

LSWR = Total annual BOD_5 load from urban stormwater runoff, in pounds per year.

LUSF = Total annual BOD_5 load from upstream flow, in pounds per year.

LWWTP = Total annual BOD_5 load from municipal and industrial wastewater treatment plant effluent, in pounds per year.

K_{11}, K_{12}, K_{13}, and K_{14} = Waste decay rates (K_1 values) for combined sewer overflow, urban stormwater runoff, upstream flow, and wastewater treatment plant effluent, respectively, in 1/day (base e).

D_1 = Duration of the year during which combined sewer overflow occurs, expressed as an absolute fraction.

D_2 = Duration of the year during which urban stormwater runoff occurs, expressed as an absolute fraction.

The areawide waste source quality parameters defined in equations 10-4 through 10-7 are waste loading rates in pounds of BOD_5 per hour multiplied by the individual decay rate of each waste. The decay rates are considered a measure of each waste's relative ability to deplete the oxygen resources of a receiving stream. That is, a waste with a small decay rate will not cause as large a maximum DO deficit as a waste with a larger decay rate.

The ability of a receiving stream to assimilate oxygen-demanding wastes is a function of the total stream flow and the receiving water reaeration capacity. The product of these variables define the denominator of equations 10-2 and 10-3. The total streamflow for wet-weather conditions (QWW) and for dry-weather conditions (QDW) are defined by the following equations.

$$QWW = \frac{QCSO}{D_1} + \frac{QSWR}{D_2} + QUSF + QWWTP \qquad (10\text{-}8)$$

and

$$QDW = QUSF + QWWTP \qquad (10\text{-}9)$$

where

QCSO = Mean annual flow from CSO, in cfs.

QSWR = Mean annual flow from SWR, in cfs.

QUSF = Mean annual upstream flow, in cfs.

QWWTP = Mean wastewater treatment plant flow, in cfs.

All other terms are as previously defined.

The dependent variable of interest is the total number of hours per year when DO levels are less than 2.0 mg/l. This variable is termed VT in the present analysis. The site studies yielded 30 observations of VT, which were used in the regression analysis. Many different models were analyzed, including linear models, semi-logarithmic models, and logarithmic models. In addition, a set of models were derived, with an additional independent variable accounting for background dissolved oxygen in the receiving water upstream from the urban area. The best model included this independent variable and is defined by the following equation.

$$VT = 1{,}013 + 864 * DWQP + 256 * WWQP - 204 * DWDO \qquad (10\text{-}10)$$

where:

VT = Total number of hours per year when the receiving water will experience dissolved oxygen levels less than 2.0 mg/l.

DWQP = Dry-weather quality parameter (Eq. 10-3).

WWQP = Wet-weather quality parameter (Eq. 10-2).

DWDO = Dissolved oxygen level occurring in the receiving water upstream from the urban area during the month of highest water temperature, in mg/l.

Dimensional analysis reveals that all three independent variables, DWQP, WWQP, and DWDO, are concentrations (i.e., M/L^3). The waste decay rate (K_1) is divided by the stream reaeration rate (K_2) and thus, dimensionally, these terms are eliminated from the DWQP and the WWQP. However, the dimensionless ratio K_1/K_2 remains; therefore, the pollutant concentrations from each waste source are adjusted by this ratio, which may be considered a waste potency factor. Equation 10-10 states that low dissolved oxygen levels are directly related to adjusted concentrations of pollutant discharge occurring during dry weather and wet weather and are inversely related to the background dissolved oxygen resources of the receiving stream.

Equation 10-10 is derived from multiple linear regression analysis of 30 receiving water impact observations generated for the 14 study sites. These data are reported in Table 10-1. Equation 10-10 has a correlation coefficient of 0.82 and a standard error of estimate of 353 hours.

Dissolved Lead (Pb)

Two criteria were established for dissolved lead: an acute criteria which limits maximum 96-hour dissolved lead levels and a chronic criteria which limits long-term dissolved lead levels. The results of the simulations indicated that the chronic or long-term criteria controlled the lead removal requirements. No acute dissolved lead problems were simulated. Therefore, the remainder of this discussion is concerned with lead removal requirements to meet the chronic or long-term dissolved lead receiving water criteria.

Table 10-1
Dissolved Oxygen Impact Data From Site Studies

Location	DWQP	WWQP	VT	DWDO	Comments
Rochester	0.681	2.865	36	8.61	Existing conditions
Rochester	0.681	0.849	1	8.61	91.1% CSO removed
Philadelphia	1.655	3.840	3,137	4.67	Existing conditions
Philadelphia	1.655	1.568	2,417	4.67	100% NPS removed
Washington	0.349	0.796	252	5.89	Existing conditions
Washington	0.349	0.341	4	5.89	92% NPS removed
Atlanta	0.181	1.266	103	8.19	Existing conditions
Atlanta	0.181	0.197	4	8.19	92% NPS removed
Des Moines	0.273	0.738	118	6.96	Existing conditions
Des Moines	0.273	0.301	25	6.96	85% NPS removed
Milwaukee	0.228	4.036	1,053	6.12	Existing conditions
Bucyrus	0.312	2.021	152	6.16	Existing conditions
Bucyrus	0.312	0.519	4	6.16	83% CSO removed
Sacramento	0.394	1.029	2	8.76	Existing conditions
Portland	0.069	0.669	6	7.76	Existing conditions
Portland	0.069	0.560	4	7.76	18% CSO removed
Durham	0.893	1.151	0	7.78	Existing conditions
Ann Arbor	0.827	1.705	10	7.04	Existing conditions
Springfield	0.436	0.400	40	6.05	Existing conditions
Tulsa	0.441	0.565	0	6.36	Existing conditions
Castro Valley	0.033	0.257	10	5.76	Existing conditions
Ann Arbor	0.827	0.472	10	7.04	100% SWR removed
Springfield	0.436	0.309	4	6.05	30% SWR removed
Castro Valley	0.033	0.224	4	5.76	13% SWR removed
Philadelphia	1.655	2.134	1,994	4.67	100% CSO and benthal demand removed
Washington	0.349	0.535	106	5.89	100% CSO removed
Atlanta	0.181	0.348	2	8.19	100% CSO and benthal demand removed
Des Moines	0.273	0.582	98	6.96	100% CSO and benthal demand removed
Milwaukee	0.228	0.574	1	6.12	100% CSO and benthal demand removed
Sacramento	0.394	0.520	0	8.76	100% CSO and benthal demand removed

Required lead removals from urban stormwater runoff and combined sewer overflow are summarized in Table 10-2. Six of the 14 study sites indicated that some lead removal is required to meet the selected criteria. Additionally, four of the six study sites which require lead removal require more than 100% removal of SWR or CSO lead to meet the selected criteria. Thus, only two of the 14 study sites indicate a lead problem which is solvable by control of SWR or CSO.

Those sites which require more than 100% removal of lead from SWR and CSO (Washington, DC; Atlanta, Georgia; Sacramento, California; and Portland, Oregon) are all located on moderate-to-large receiving waters with low hardness and large background (i.e., upstream flow) lead loads. Thus, long-term dissolved lead levels are dominated by receiving water background conditions and not by lead washoff from the urban area. Therefore, the "need" for removal of lead from urban runoff waters in these cases is questionable and cannot be justified by the present data base.

The remaining sites which require lead removal of less than 100% of the total SWR lead load (Tulsa, Oklahoma, and Castro Valley, California) are stormwater sites located on small receiving streams. The receiving water hardnesses of 219 mg/l for Tulsa, Oklahoma, and 100 mg/l for Castro Valley, California, are also fairly low. It is noted that, in these two cases, the required suspended solids removal is greater than the required lead removal and that selection of a treatment level which will provide the required suspended solids removal will also provide the required lead removal. Thus, in these cases, no "additional needs" would be required to meet the dissolved lead criteria.

Therefore, based on the results of the 14 receiving water impact studies, lead removal requirements are not considered directly in the estimation of national needs for Categories V and VI.

Although no nationally applicable method for estimating lead removal requirements could be obtained from the results of the site studies, several conclusions can be made.

1. Our understanding of dissolved lead toxicity in natural waters is inadequate to establish justifiable limits. Much additional research on both acute and chronic lead toxicity for a number of representative species is required.

2. The data base on which background receiving water lead concentrations are determined is inadequate. Background lead has been shown to dominate the system on four of the six study sites which indicate a potential dissolved lead problem. Data which define background receiving water lead concentrations are few and quite variable.

3. Receiving waters with background hardness greater than approximately 250 mg/l are unlikely to experience dissolved lead toxicity problems.

Table 10-2
Summary of Lead Removal Data

Study Site	Required Lead Removal (percent)	Receiving Water Hardness (mg/l)	Percent of Total Load from SWR and/or CSO	Percent of Total Load from Upstream Flow
Rochester, New York	0	125	1.7	91.5
Philadelphia, Pennsylvania	0	116	20.0	67.2
Washington, DC	>100	110	15.7	81.8
Atlanta, Georgia	>100	10	43.7	51.8
Bucyrus, Ohio	0	300	51.4	46.0
Milwaukee, Wisconsin	0	337	90.0	10.0
Des Moines, Iowa	0	341	80.0	17.1
Sacramento, California	>100	60	4.8	92.9
Portland, Oregon	>100	24	4.6	95.1
Durham, North Carolina	0	50	98.7	0.0
Ann Arbor, Michigan	0	267	85.0	15.0
Springfield, Missouri	0	153	91.7	5.2
Tulsa, Oklahoma	40	219	82.0	17.4
Castro Valley, California	95	100	98.4	1.6

4. Design of stormwater management systems based on the suspended solids and dissolved oxygen criteria outlined in this report will result in substantial watershed lead removals. Additional removals, if any, necessary to obtain acceptable receiving water dissolved lead concentrations are indeterminate at this time.

Phosphorus (P)

Phosphorus is a nutrient which, in the United States, is largely the controlling nutrient in the lake eutrophication process. Only one study site, Syracuse, New York, discharges directly to a lake, although many others discharge indirectly to lakes. The Syracuse, New York, site study indicated a phosphorus removal requirement of 80% from the combined sewer overflow portion of the load.

In general, combined sewer overflow and urban stormwater runoff are not the predominate sources of phosphorus generated by urban land use. The predominate source is wastewater treatment plant effluent. For example, if an urban watershed is served entirely by combined sewers, wastewater treatment plant effluent will account for approximately 80% of the annual phosphate phosphorus load, while CSO will account for only 20%. If the urban watershed is served 25% by combined sewers and 75% by separate sewers, which is somewhat more typical, then the phosphate phosphorus contribution from CSO and SWR drops to 10% of the annual load and the wastewater treatment plant portion of the annual load increases to 90%.[1] Therefore, control of phosphorus is largely a function of wastewater treatment plant design (Categories I through IVB in the Needs Survey) and not of urban stormwater management (Categories V and VI). However, an allowance is made for phosphate removal from combined sewer overflow and urban stormwater runoff when discharge is directly to a lake.

A recent study of nutrient removal from combined sewer overflow indicates that coagulation-flocculation with chemical addition followed by high-rate filtration is effective in removing phosphorus as well as ammonia.[2] Suspended solids removals were in the range of 90% to 100% and total inorganic phosphorus removals were above 91%. This treatment train corresponds to Treatment Level 4 as defined in Chapter 5. BOD_5 and SS removals for Level 4 were previously assumed to be 91% and 99%, respectively (see Table 5-3). Therefore, phosphorus removals for Treatment Level 4 are approximately equal to BOD_5 removals. Therefore, for the purpose of the Needs Survey if discharge is directly to a lake, required BOD_5 removal is set equal to 80%, which will assure selection of Treatment Level 4 as a minimum and removal of at least 80% of the annual phosphorus load.

ECONOMIC OPTIMIZATION

The economic optimization analysis presented in Chapter 9 provides insight into the mix of techniques which should be used to obtain various levels of pollutant removal for both combined and separate watersheds. Topics discussed in this section of Chapter 10 include pollutant removal by type of watershed, pollutant removal from streetsweeping, pollutant removal from sewer flushing, and pollutant removal from storage/treatment systems.

Pollutant Removal by Sewer System Type

For watersheds served by both combined and separate sewers, the first question to be addressed is how much of a given desired areawide pollutant removal should be obtained from the combined portion of the watershed and how much should be obtained from the separate sewered portion of the watershed. The results of the site studies related to optimum removal by sewer system type have been reported in Tables 9-6, 9-7, 9-8, and 9-9. Regression analysis of these data against selected pollutant loading parameters yields the following equations.

$$\mathrm{REMSWR} = 0.926 * \mathrm{TOTREM} - 2.696 * \mathrm{LDRAT} + 111.92 * \mathrm{ARAT} \qquad (10\text{-}11)$$

$$\mathrm{REMCSO} = 0.502 * \mathrm{TOTREM} + 2.864 * \mathrm{LDRAT} - 50.48 * \mathrm{ARAT} \qquad (10\text{-}12)$$

where

REMSWR = Pollutant removal obtained from SWR portion of basin in percent of total SWR load.

REMCSO = Pollutant removal obtained from combined sewered portion of basin, in percent of total CSO load.

TOTREM = Total areawide pollutant removal required, in percent of total areawide load.

LDRAT = Load ratio defined as the unit pollutant yield from the combined portion of the watershed, in pounds per acre per year, divided by the unit pollutant yield from the separate portion of the watershed, in pounds per acre per year.

ARAT = Area ratio, defined as the combined sewer service area divided by the total area.

Equations 10-11 and 10-12 have correlation coefficients of 0.973 and 0.839, respectively, and were derived for total removal requirements in the range of 10% to 90%. The load ratio was in the range of 0.854 to 14.56 and the area ratio was in the range of 0.082 to 0.175.

Pollutant Removal from Streetsweeping

The results of the economic optimization analysis relating streetsweeping level of effort to desired pollutant removal did not lend themselves to regression analysis because of discontinuities in the data. Therefore, these data were analysed graphically, as shown in Figures 10-1 and 10-2.

Figure 10-1 illustrates the relationship between optimum streetsweeping level of effort (X_{sw}, fraction of streets swept daily) and pollutant removal, in percent, for areas served by separate sewers. Also shown on Figure 10-1, as a solid line, is the relationship used to select an appropriate streetsweeping level of effort given an overall required pollutant removal. Figure 10-2 is a similar illustration for areas served by combined sewers. The discontinuity in the data occurs in the range of 30% to 40% pollutant removal and represents the point where storage/treatment systems become cost-effective. Once storage/treatment systems enter into the mix, the relative use of streetsweeping declines. However, as can be seen from Figures 10-1 and 10-2, some streetsweeping is used throughout the entire range of pollutant removals.

Pollutant Removal from Sewer Flushing

The results of the economic optimization analysis relating sewer flushing level of effort (X_{sf}, fraction of sewers flushed daily) to desired pollutant removal were also analyzed graphically, as shown in Figure 10-3. These data exhibit the same discontinuity and overall behavior as the streetsweeping data. Maximum level of effort occurs at approximately 40% overall pollutant removal, and some sewer flushing is used for nearly all desired pollutant removals.

Pollutant Removal from Storage/Treatment Systems

Once the optimum level of effort for sewer flushing and streetsweeping are known, these levels of effort can be converted to fraction of pollutants removed by application of the production functions presented in Figures 6-3 and 6-4 and equations 6-6 and 6-9. If these removals are insufficient to satisfy the total required removal, then the remainder must be removed by a storage/treatment system. The removal required by storage/ treatment is computed by the following equation.

$$STR = \frac{TR - MPR}{100 - MPR} * 100 \qquad (10-13)$$

where

STR = Pollutant removal required from storage/treatment system in percent of total load.

TR = Total pollutant removal desired, in percent.

MPR = Total pollutant removal obtained from management practices, in percent.

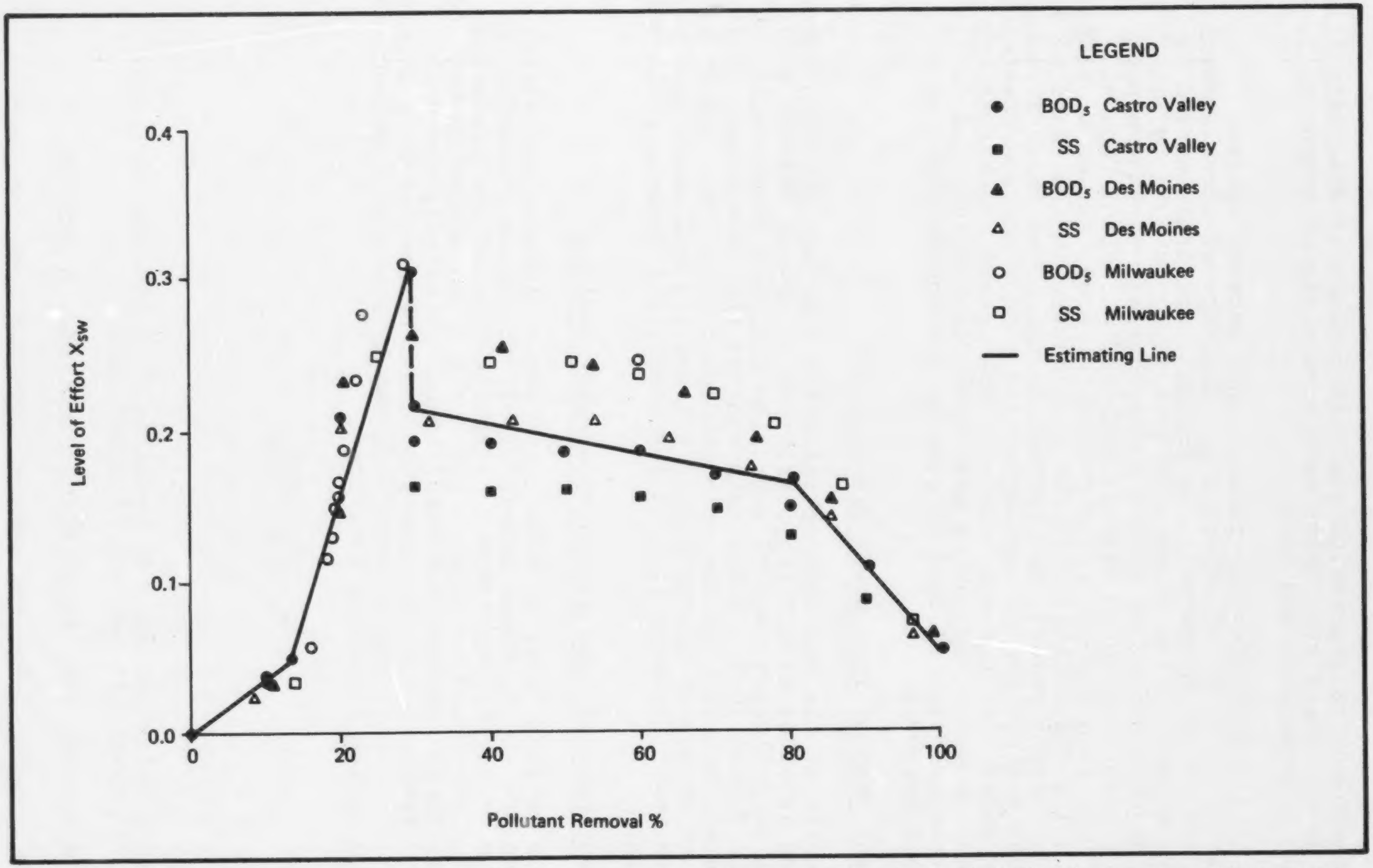


FIGURE 10-1. Relationship between desired pollutant removal and optimum streetsweeping level of effort for areas served by separate sewers.

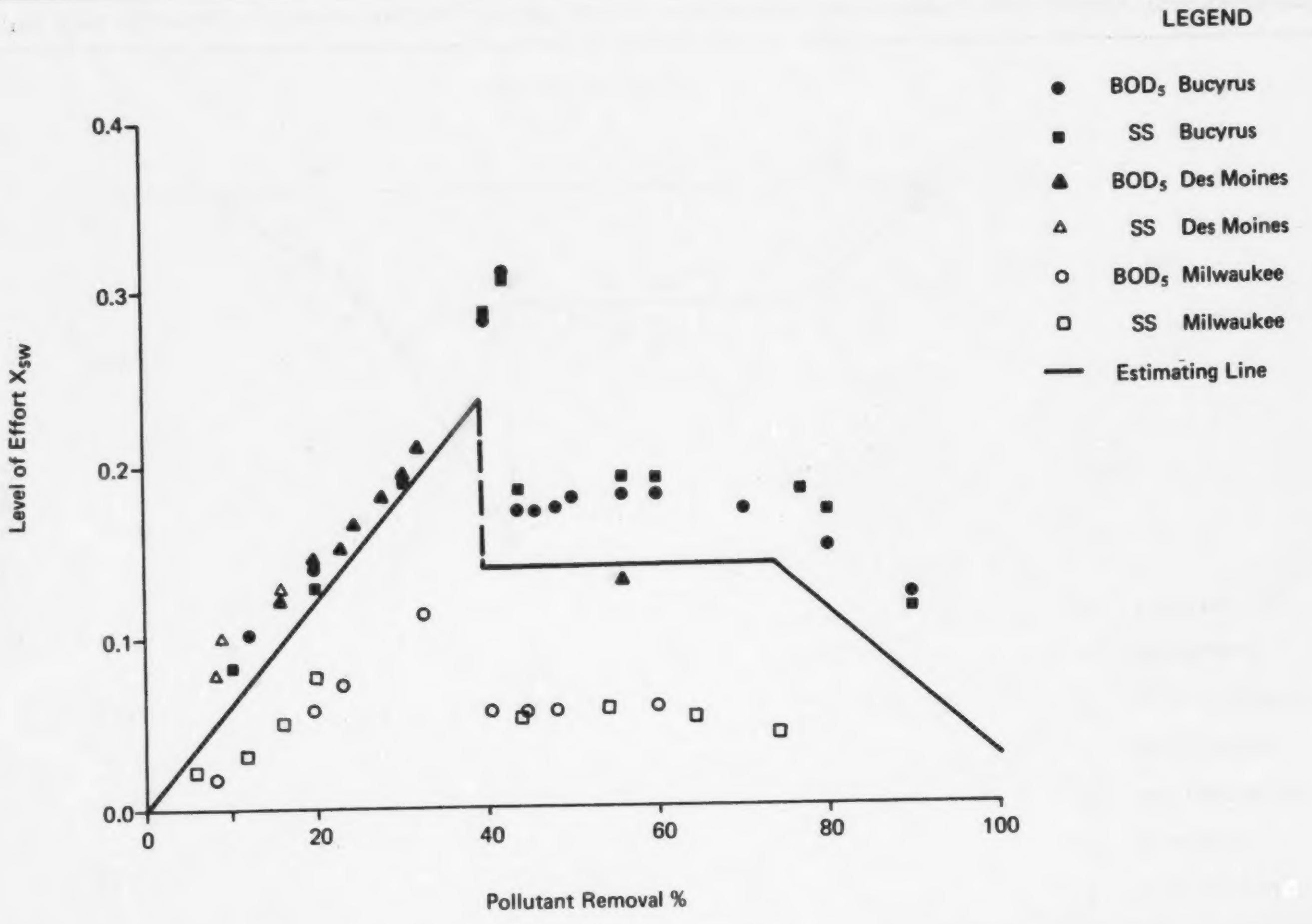


FIGURE 10-2. Relationship between desired pollutant removal and optimum streetsweeping level of effort for areas served by combined sewers.

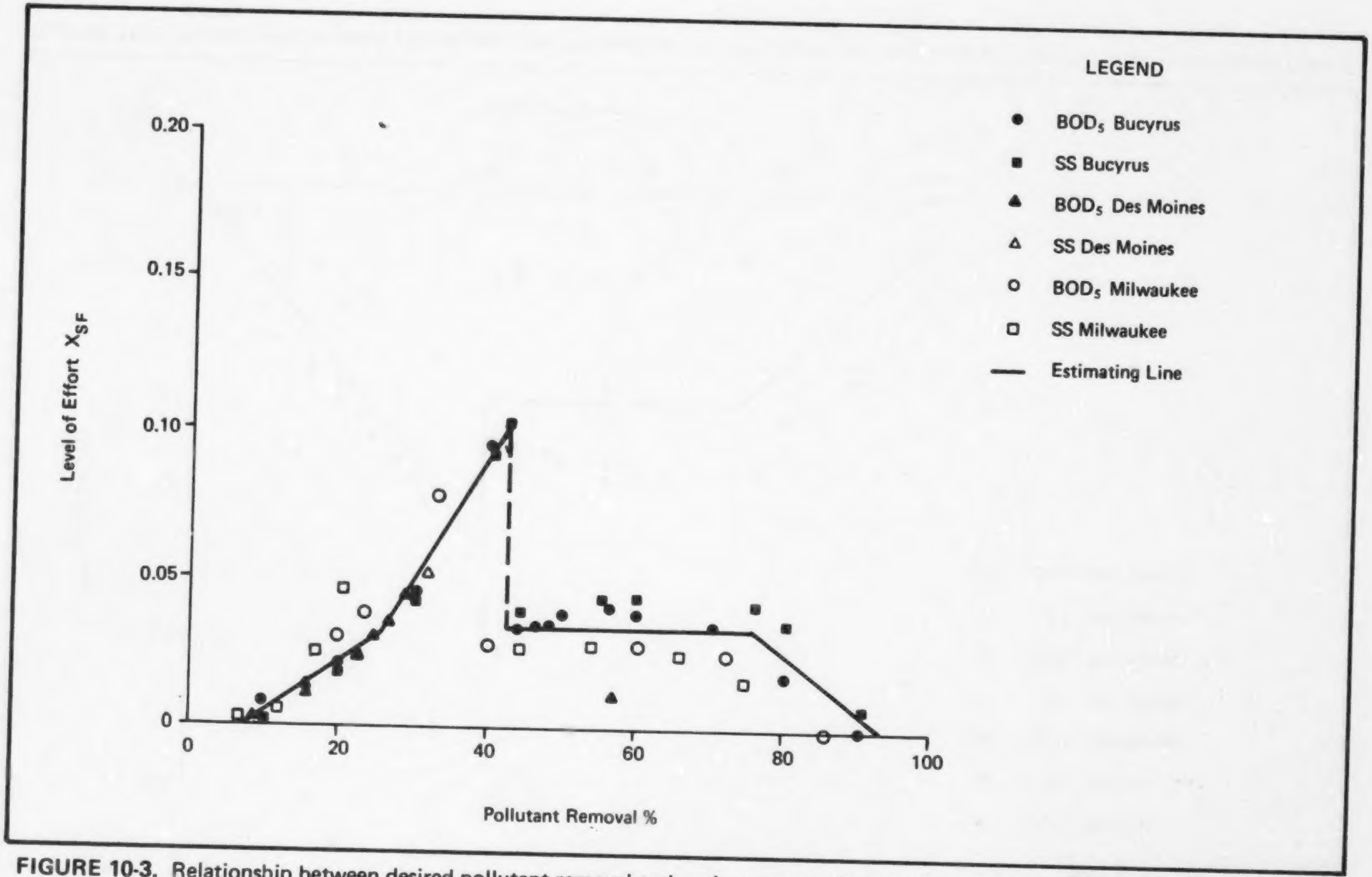


FIGURE 10-3. Relationship between desired pollutant removal and optimum sewer flushing level of effort for areas served by combined sewers.

The optimum treatment level is a function of the removal required from the storage/treatment system, STR, the pollutant type (SS or BOD), and the sewer system type (separate or combined). Selection of the optimum treatment level is defined in Table 10-3. Once the required removal and treatment levels are known, then the optimum storage volume and treatment rate may be obtained by application of the storage/treatment isoquants presented in Chapter 6.

REFERENCES

1. Wycoff, R. L., J. E. Scholl, and M. J. Mara. "Report to Congress on Control of Combined Sewer Overflow in the United States." EPA 430/9-78-006. October 1978.

2. Murphy, C. B., Jr., O. Hrycyk, and W. T. Gleason. "High-Rate Nutrient Removal for Combined Sewer Overflows--Bench Scale and Demonstration Scale Studies." EPA 600/2-78-056. June 1978.

PART IV

NEEDS ESTIMATE

Chapter 11
NATIONAL DATA BASE

NATIONAL COMBINED SEWER SYSTEM DATA FILE

The purpose of the National Combined Sewer System Data File is to assemble certain basic data on each combined sewer system in the nation. These data include location, sewer system characteristics, receiving water characteristics, and the status of CSO correction planning.

The actual data gathering effort was conducted by Dames and Moore, Inc., who served as consultants on the Categories I through IV B portion of the Needs Survey. Guidelines and a combined sewer system worksheet were provided by CH2M HILL.

Combined Sewer System Worksheet

Because of the dual role provided by combined sewer systems, i.e., urban drainage and wastewater conveyance, they cannot be entirely defined on a facility-by-facility basis, but must be defined by hydrologic considerations. For this reason, a separate worksheet was completed for each combined sewer system/major receiving water combination. One worksheet covered more than one combined sewer network if the networks are adjacent and discharge to the same major receiving water. Thus, a single worksheet may cover any number of overflow points on either side of a given receiving water so long as they are located in the same general area and discharge to a single receiving water.

The definition of a major receiving water is somewhat subjective. However, an attempt was made to define a receiving water as objectively as possible. If a combined sewer system discharges directly to a lake, an ocean, or a major stream, then the receiving water in each case is obvious. Receiving water definition problems may arise where discharge is to small urban streams which feed larger streams. The question then arises as to whether or not a given stream should be considered a major receiving water. The criteria used to define a receiving water are given as follows. If the reach in question is a continuously flowing stream which could, in its natural state, support a viable fishery, then this stream was considered a receiving water, and a worksheet was completed for that combined sewer network/receiving water system.

In general, if a stream is wholly contained within a combined sewer watershed, then the stream was not considered a major receiving water. On the other hand, if the stream drains a significant watershed area upstream from the combined sewer area, then the stream was considered a major receiving water.

Description of Items on Worksheet

Figure 11-1 is a copy of the combined sewer system worksheet. Figure 11-2 is the back of the worksheet, which defines the worksheet items. These items are defined in more detail as follows.

Item 1--Authority/Facility Number. The authority/facility number is defined in the Guidance for Categories I-IV. The number reported on this form is for the major facility serving the combined sewer system.

Item 2--Authority Name. The official name of the authority with major responsibility for operation of the combined sewer system.

Item 3--State, County, Place. The state, county, place code is defined in the Guidance for Categories I-IV. This code applies to the facility reported in Item 1.

Item 4--SMSA. A code which indicates whether or not the combined sewer system is located at least in part within a standard metropolitan statistical area (SMSA) as follows:

0--Combined sewer system is not located within an SMSA.

1--Combined sewer system is located, at least in part, within an SMSA.

Item 5--Basin. The basin code is defined in the Guidance for Categories I-IV. This code applies to the location of the combined sewer system.

Item 6--Congressional District. The number of the congressional district(s) which are served by the combined sewer system.

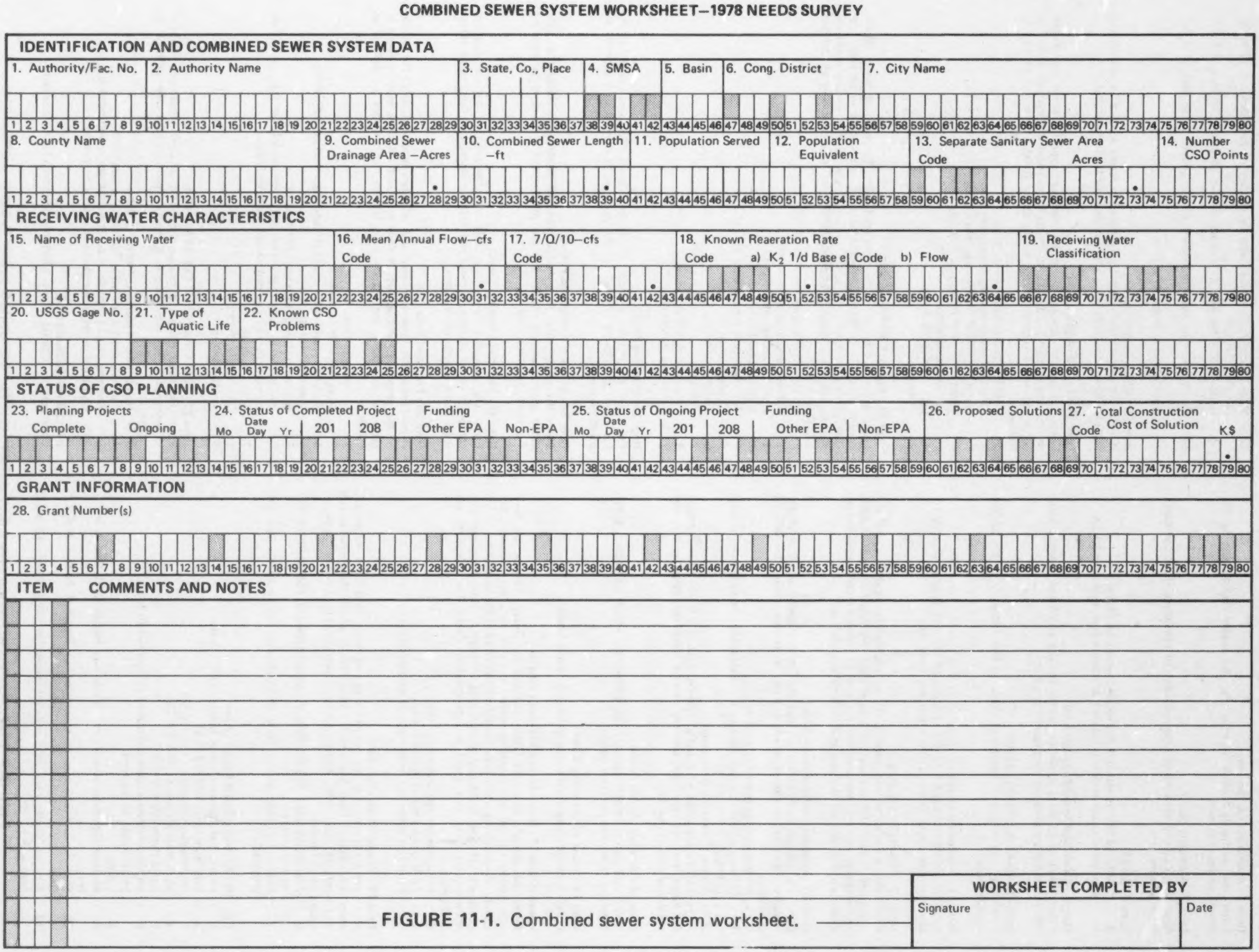
Item 7--City Name. The official name of the city or town served by the combined sewer system.

Item 8--County Name. The official name of the county or county equivalent in which the major portion of the combined sewer system is located.

Item 9--Combined Sewer Drainage Area. The area in acres drained directly by the combined sewer system which is tributary to the subject receiving water.

Item 10--Combined Sewer Length. The total length of combined sewer in feet tributary to the subject receiving water. In general, total combined sewer lengths will range between 50 and 350 feet per acre and average about 165 feet per acre.

Item 11--Population Served. The total number of people resident to the area drained directly by the combined sewer system defined



COMBINED SEWER SYSTEM WORKSHEET—1978 NEEDS SURVEY

IDENTIFICATION AND COMBINED SEWER SYSTEM DATA

1. Authority/Fac. No.
2. Authority Name
3. State, Co., Place
4. SMSA
5. Basin
6. Cong. District
7. City Name

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

8. County Name
9. Combined Sewer Drainage Area —Acres
10. Combined Sewer Length —ft
11. Population Served
12. Population Equivalent
13. Separate Sanitary Sewer Area — Code — Acres
14. Number CSO Points

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

RECEIVING WATER CHARACTERISTICS

15. Name of Receiving Water
16. Mean Annual Flow—cfs — Code
17. 7/Q/10—cfs — Code
18. Known Reaeration Rate — Code — a) K_2 1/d Base e — Code — b) Flow
19. Receiving Water Classification

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

20. USGS Gage No.
21. Type of Aquatic Life
22. Known CSO Problems

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

STATUS OF CSO PLANNING

23. Planning Projects — Complete — Ongoing
24. Status of Completed Project — Date: Mo Day Yr — 201 — 208 — Funding: Other EPA — Non-EPA
25. Status of Ongoing Project — Date: Mo Day Yr — 201 — 208 — Funding: Other EPA — Non-EPA
26. Proposed Solutions
27. Total Construction Cost of Solution — Code — K$

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

GRANT INFORMATION

28. Grant Number(s)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

ITEM **COMMENTS AND NOTES**

WORKSHEET COMPLETED BY

Signature

Date

FIGURE 11-1. Combined sewer system worksheet.

CODE REFERENCE CHART AND DEFINITIONS

Item 1 - Authority/Facility No.
Enter the authority/facility number for the major facility serving the combined sewer system.

Item 2 - Authority Name
Name of authority with major responsibility for operation of the combined sewer system.

Item 4 - SMSA
0 - Combined sewer system is not located within an SMSA.
1 - Combined sewer system is located, at least in part, within an SMSA.

Item 9 - Combined Sewer Drainage Area
Enter the area in acres drained directly by the combined sewer system which is tributary to the subject receiving water.

Item 10 - Combined Sewer Length
Enter the total length of combined sewer in feet tributary to the subject receiving water.

Item 11 - Population Served
Enter the total number of people resident to the area drained directly by the combined sewer system defined in Items 9 and 10.

Item 12 - Population Equivalent
Enter the wastewater (dry-weather flow) population equivalent for the combined sewer system. Population equivalent is defined on a BOD basis and includes the resident population (Item 12), commercial contribution, existing industrial contribution, and transient population.

Item 13 - Separate Sanitary Sewer Area
Enter the area in acres served by separate sanitary sewers which discharge directly into the combined sewer system, if known. Codes are defined as follows:
0 - No information presently available.
1 - Some separate sanitary sewers are connected; however, the area is unknown.
2 - Area is known and is reported.
Note that a code value of 2 and a reported area of 0.0 will be interpreted to mean that no separate sanitary sewers discharge directly into the combined sewer system.

Item 14 - Number of CSO Points
Enter the approximate number of points at which combined sewer overflow enters the receiving water.

Item 15 - Name of Receiving Water
Enter common name of receiving water, e.g., Rock Creek.

Items 16 and 17 - Mean Annual Flow and 7/Q/10
Enter the average flow rate (Item 16) and the 7-day, 10-year low flow rate (Item 17) of the receiving water in cubic feet per second (cfs). Ideally, the receiving water flow should be measured at the upstream boundary of the combined sewer area. However, flow measurements or estimates near this point are acceptable. Codes for this item are as follows:
0 - Flow rate not applicable, e.g., lake.
1 - Flow rate measured at USGS gage.
2 - Flow rate estimated from regional relationship.

Item 18 - Known Reaeration Rate
If a reaeration rate for the subject receiving water has been measured, enter the value in Item 18a and the flow rate at which the measurement was made in Item 18b. Units of the reareation rate are day^{-1} base e. Codes are as follows:
0 - Reaeration rate and/or flow measurements are not available for receiving water.
1 - Reaeration rate and/or flow measurements are available and are reported.

Item 19 - Receiving Water Classification
1 - Creeks and shallow streams (depth (d) < 2 feet).
2 - Upstream feeders ($2 \leq d < 5$).
3 - Intermediate channels ($5 \leq d < 10$).
4 - Main drainage rivers ($10 \leq d < 20$).
5 - Large rivers ($20 \leq d < 30$).
6 - Impounded rivers (flow controlled or depth ≥ 30 feet).
7 - Small ponds, backwaters.
8 - Lakes.
9 - Shallow high tidal velocity estuary or bay (depth < 10 feet, $V \geq 1.5$ fps).
10 - Shallow, low tidal velocity estuary or bay (depth < 10 feet, $V < 1.5$ fps).
11 - Medium depth, high tidal velocity estuary or bay (depth = 10 to 30 feet, $V \geq 1.5$ fps).
12 - Medium depth, low tidal velocity estuary or bay (depth = 10 to 30 feet, $V < 1.5$ fps).
13 - Deep, high tidal velocity estuary or bay (depth > 30 feet, $V \geq 1.5$ fps).
14 - Deep, low tidal velocity estuary or bay (depth > 30 feet, $V < 1.5$ fps).
15 - Open ocean or beach.

Item 20 - USGS Gage Number
If receiving water flow estimates reported in Items 17 and 18 are derived from USGS flow records, enter the station identification number.

Item 21 - Type of Aquatic Life
Enter the type of aquatic life which could be supported under unpolluted or uncontaminated conditions in the receiving water downstream from the combined sewer system. Codes which apply to this item are defined as follows:
1 - Cold freshwater fishery, e.g., trout.
2 - Cold freshwater nursery or breeding area.
3 - Warm freshwater fishery, e.g., black bass.
4 - Warm freshwater nursery or breeding area.
5 - Estuary nonshellfish.
6 - Estuary shellfish waters.
7 - Open ocean.

Item 22 - Known CSO Problems
Enter water quality problems associated with the receiving water downstream from the combined sewer area which are known to be caused at least in part by combined sewer overflow. Up to four known problems may be entered in order of importance from left to right. Codes are defined as follows:
0 - No known problems.
1 - Esthetic degradation.
2 - High suspended solids levels.
3 - Low dissolved oxygen levels.
4 - Bacteriological contamination.
5 - Sludge deposits.
6 - Toxic conditions.
7 - Fish kills.
8 - Eutrophication (nutrients).
9 - Other, see comments.

Item 23 - Planning Projects
Enter a 1 in columns 4 and/or 10 if the subject combined sewer system has been or is being studied for the purpose of control or treatment of overflow events.

Item 24 - Status of Completed Project
Enter the completion date, mo/day/year, of most-recent completed combined sewer planning project and indicate method of funding by entering 1 in the appropriate column.

Item 25 - Status of Ongoing Project
Enter the expected completion date, mo/day/year, of current ongoing combined sewer planning project and indicate method of funding by entering 1 in the appropriate column.

Item 26 - Proposed Solutions
If problems have been identified and solutions proposed, enter the nature of the proposed solution. Up to four proposed solutions may be listed in order of decreasing importance from left to right. Codes are defined as follows:
1 - Sewer separation.
2 - Storage/treatment system.
3 - High rate treatment without storage (e.g., swirl concentrator).
4 - In-system storage.
5 - In-system storage with real-time control.
6 - Surface water interception/storage/diversion scheme (i.e., runoff diverted before entering combined sewer system).
7 - Sewer flushing.
8 - Catch basin cleaning.
9 - Streetsweeping.

Item 27 - Total Construction Cost of Solution
Enter the total estimated construction cost of CSO abatement facilities recommended in most-recent planning study. Codes are defined as follows:
0 - No completed planning project to date.
1 - Planning project complete, but report unavailable.
2 - Planning project complete—construction not recommended.
3 - Construction recommended and costs are reported.

Item 28 - Grant Number(s)
Enter grant number(s), if any, which provide funds for CSO control.

FIGURE 11-2. Code reference chart and definitions for combined sewer system worksheet.

in Items 9 and 10. In general, population densities will range from 5 to 75 persons per acre and average about 17 persons per acre.

Item 12--Population Equivalent. The dry-weather flow population equivalent for the combined sewer area defined on a BOD basis and includes the resident population (Item 11), commercial contribution, existing industrial contribution, and transient population. Population equivalent was computed on the basis of 0.17 pounds BOD_5 per person per day.

Item 13--Separate Sanitary Sewer Area. The area in acres served by separate sanitary sewers which discharge directly into the combined sewer system, if known.

Codes are defined as follows:

0--No information presently available.

1--Some separate sanitary sewers are connected; however, the area is unknown.

2--Area is known and is reported.

A code value of 2 and a reported area of 0.0 indicates that no separate sanitary sewers discharge directly into the combined sewer system.

Item 14--Number of CSO Points. The number of points at which the combined wastewater/stormwater is discharged from the collection system directly into the receiving water during periods of high flow.

Item 15--Name of Receiving Water. This is the common name of the receiving water such as "Rock Creek."

Items 16 and 17--Mean Annual Flow and 7/Q/10. These are the average flow rate (Item 16) and the 7-day, 10-year low flow rate (Item 17) of the receiving water in cubic feet per second (cfs). Ideally the receiving water flow should be measured at the upstream boundary of the combined sewer area. However, flow measurements or estimates near this point were often used.

In most cases, the United States Geological Survey provided flow records or general flow studies for rivers within their jurisdiction. These records provide information sufficient to establish mean and low flow conditions within the context of this survey. Codes for this item are as follows.

0--Flow rate not applicable, e.g., lake.

1--Flow rate measured at USGS gage.

2--Flow rate estimated from regional relationship.

Item 18--Known Reaeration Rate. If a reaeration rate for the subject receiving water was known, the value was entered in Item 18a and the flow rate at which the measurement was made in Item 18b. Units of the reaeration rate are day^{-1} base e.

Codes are as follows:

0--Reaeration rate and/or flow measurements are not available for receiving water.

1--Reaeration rate and/or flow measurements are available and are reported.

Item 19--Receiving Water Classification. The purpose of the receiving water classification is to describe the general characteristics of the receiving water. A verbal description is used to place the receiving water in 1 of 15 separate categories. Values and ranges of depth and/or velocity were given on the code reference chart (Figure 11-2) to guide in the selection of the proper category. Depths and velocities are mean values and apply to mean flow conditions.

Codes for this item are as follows:

1--Creeks and shallow streams (depth (d) <2 feet).

2--Upstream feeders ($2 \le d < 5$).

3--Intermediate channels ($5 \le d < 10$).

4--Main drainage rivers ($10 \le d < 20$).

5--Large rivers ($20 \le d < 30$).

6--Impounded rivers (flow controlled or depth ≥ 30 feet).

7--Small ponds, back waters.

8--Lakes.

9--Shallow high tidal velocity estuary or bay (depth <10 feet, $V \ge 1.5$ fps).

10--Shallow, low tidal velocity estuary or bay (depth <10 feet, $V \ge 1.5$ fps).

11--Medium depth, high tidal velocity estuary or bay (depth = 10 to 30 feet, $V \ge 1.5$ fps).

12--Medium depth, low tidal velocity estuary or bay (depth = 10 to 30 feet, $V < 1.5$ fps).

13--Deep, high tidal velocity estuary or bay (depth >30 feet, V ≥1.5 fps).

14--Deep, low tidal velocity estuary or bay (depth >30 feet, V <1.5 fps).

15--Open ocean or beach.

Item 20--USGS Gage Number. If receiving water flow estimates reported in Items 16 and 17 were derived directly from USGS flow records, the station identification number, is reported here.

Item 21-Type of Aquatic Life. The type of aquatic life which could reasonably be supported under unpolluted or uncontaminated conditions in the receiving water downstream from the combined sewer system, is reported in Item 21.

Codes which apply to this item are defined as follows:

1--Cold freshwater fishery, e.g., trout.

2--Cold freshwater nursery or breeding area.

3--Warm freshwater fishery, e.g., black bass.

4--Warm freshwater nursery or breeding area.

5--Estuary nonshellfish.

6--Estuary shellfish waters.

7--Open ocean.

Item 22--Known CSO Problems. Water quality problems associated with the receiving water downstream from the combined sewer area which are known to be caused at least in part by combined sewer overflow. Up to four known problems may be entered in order of importance from left to right.

Codes are defined as follows:

0--No known problems.

1--Aesthetic degradation.

2--High suspended solids levels.

3--Low dissolved oxygen levels.

4--Bacteriological contamination.

5--Sludge deposits.

6--Toxic conditions.

7--Fish kills.

8--Eutrophication (nutrients).

9--Other.

Items 23, 24, and 25--Planning Projects, Status of Completed Project, and Status of Ongoing Project. The purpose of these items is to establish the overall status of combined sewer overflow pollution abatement planning in the United States. Data requirements are defined as follows.

Item 23--Planning Projects. A 1 in columns 4 and/or 10 indicates that the subject combined sewer system has been or is being studied for the purpose of control or treatment of overflow events.

Item 24--Status of Completed Project. The completion date, month/day/year, of the most recently completed combined sewer planning project and method of funding.

Item 25--Status of Ongoing Project. The expected completion date, month/day/year, of a current ongoing combined sewer planning project and method of funding.

Item 26--Proposed Solutions. If problems have been identified and solutions proposed, the nature of the proposed solution was reported. Up to four proposed solutions were listed in order of decreasing importance from left to right.

Codes are defined as follows:

1--Sewer separation.

2--Storage/treatment system.

3--High rate treatment without storage (e.g., swirl concentrator).

4--In-system storage.

5--In-system storage with real-time control.

6--Surface water interception/storage/diversion scheme (i.e., runoff diverted before entering combined sewer system).

7--Sewer flushing.

8--Catch basin cleaning.

9--Streetsweeping.

3. 1974 Needs booklet.

4. Grants file.

5. 208 plans.

6. 201 plans.

7. Telephone survey to municipalities.

Results

A total of 1,241 completed worksheets were received from Dames and Moore. These worksheets were screened for facilities which discharge to a common receiving water in the same municipality. When this situation was encountered, multiple worksheets were combined into a single worksheet for that urban area/receiving water system. This situation was encountered only in the States of New Jersey, New York, and Pennsylvania. The resulting data file contains information on 1,143 combined sewer systems nationwide.

URBANIZED AREA DATA BASE

The Urbanized Area Data Base is used directly in the estimation of Categories V and VI needs. Category V needs for areas served by combined sewers existing both within and outside of urbanized areas are estimated by use of subsets of the National Combined Sewer System Data File.

In the regulations for application of the NPDES Permit Program to separate storm sewers, the term "separate storm sewer" is defined as "a conveyance or system of conveyances.... located in an urbanized area and primarily operated for the purpose of collecting and conveying stormwater runoff."[1] Based on this definition, the urbanized areas, as designated by the U.S. Bureau of the Census, are used as the geographical areas which required control and/or treatment of urban stormwater runoff. Therefore, needs estimates for both Categories V and VI are required within Urbanized Areas.

The specific criteria for the delineation of an Urbanized Area are as follows.

1. A central city of 50,000 inhabitants or more, or twin cities with a combined population of at least 50,000, and with the smaller of the twin cities having a population of at least 15,000.

2. Surrounding closely settled territory, including the following.

    a. Incorporated places of 2,500 inhabitants or more.

    b. Incorporated places with fewer than 2,500 inhabitants, provided that each has a closely settled area of 100 housing units or more.

c. Small parcels of land normally less than one square mile in area having a population density of 1,000 inhabitants or more per square mile.

d. Other similar small areas in unincorporated territory with lower population density provided that they serve to eliminate enclaves, or to close indentations in the urbanized ares of 1 mile or less across the open end, or to line outlying enumeration districts of qualifying density that are not more than 1-1/2 miles from the main body of the Urbanized Area.

As of 1 January 1978, there were 279 Urbanized Areas defined in the nation. Thirty-five of the Urbanized Areas encompassed area in two states and three urbanized areas encompassed area in three states. By subdividing by state the Urbanized Areas encompassing lands in more than one state, a total of 320 areas were defined for estimation of Category V and VI needs.

The Urbanized Area Data Base consists primarily of the following items, some of which were obtained from the National Combined Sewer System Data File and the remainder were obtained from other published sources.

1. Demographic data.

    a. The items in this category are the combined sewer service area and the population served by combined sewers, the Urbanized Area population and size, the year 1970 SMSA population, and year 2000 SMSA population estimate, and the citywide EPA construction cost factor.

2. Hydrologic data.

    a. The items in this category are the number of days with rain per year, the mean annual rainfall, the receiving water classification, the mean annual flow of the receiving water, and the natural runoff coefficient.

3. Water quality data.

    a. The items in this category are maximum monthly receiving water temperature, background BOD, suspended solids lead background hardness, alkalinity and pH of the receiving water.

Sources of Data

1. Demographic data.

    a. The combined sewer service area and the population served by the combined sewers were taken from the National Combined Sewer System Data File for those systems located within Urbanized Areas.

b. Urbanized Area population and size were reported from the supplementary report of the 1970 census of population.[2]

c. 1970 SMSA population was reported in the "Current Population Reports Series."[3]

d. Year 2000 SMSA population estimates were reported from the U.S. Water Resources Council's OBERS Projections.[4]

e. Citywide EPA construction cost factor was taken from EPA Municipal Construction Cost Index Map, Wastewater Treatment Plants, City multipliers.

2. Hydrologic data.

   a. The number of days with rain per year and the mean annual rainfall were obtained from the National Oceanic and Atmospheric Administration.[5]

   b. Receiving water data were obtained from the National Combined Sewer System Data File and from USGS water resources data.[6]

   c. Natural runoff coefficient were obtained from U.S. Geological Survey Water Supply Paper 1797--"Has the United States Enough Water?"[7]

3. Water quality data.

   a. Background water quality data were obtained from the Assessment of Water Pollution from nonpoint Sources[8]

The Urbanized Area data base is presented in Appendix B.

NON-URBANIZED AREA DATA BASE

In addition to the Categories V and VI needs estimates developed on an Urbanized Area basis, an estimate of Category V needs was made for all combined sewer systems located outside of Bureau of Census-defined Urbanized Areas. These data are developed for each state and are similar to the Urbanized Area data. Included are total combined sewer areas located outside of Urbanized Areas, population served by those systems, total number of systems, total number of CSO points, annual number of days with rain, mean annual rainfall, mean receiving water flow, background receiving water BOD and SS, the EPA construction cost factor, and the natural runoff coefficient. These data are reported in Appendix C.

Sources for this information are the same as those reported for the Urbanized Area data base. The mean receiving water flow for each state was computed as the combined sewer area weighted average of the receiving water flows, reported on the National Combined Sewer System Data File.

REFERENCES

1. Federal Register, 40 CFR Parts 124, 125, National Pollution Discharge Elimination System--Separate Storm Sewers, Final Regulations. 18 March 1976.

2. Supplementary report 1970 Census of Population, PC(S7)-106. Population of urbanized areas established in the 1970 census for the United States. 1970.

3. Population estimates and projections, P-25, No. 709. Estimates of the Population of counties and metropolitan areas. 1 July 1974 and 1975.

4. U.S. Water Resources Council, 1972, OBERS Projections of Economic Activity in the U.S., Volume IV--States, Volume V--Standard Metropolitan Statistical Areas, Washington, DC.

5. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Climates of the States, Vol. I and Vol. II. 1974.

6. U.S. Department of Interior, Geological Survey, "Water Resources Data for the United States." Published annually for each state.

7. Piper, A. M. Has the United States Enough Water? U.S. Geological Survey Water Supply Paper 1797. U.S. Government Printing Office, Washington, DC. 1965.

8. McElroy, A. D., et al. Loading Functions for Assessment of Water Pollution from Nonpoint Sources. EPA 600/2-76/151. May 1976.

Chapter 12
NEEDS ESTIMATION TECHNIQUE

A needs estimation computer program for Categories V and VI was developed specifically for the 1978 Needs Survey. This program calculates present and year 2000 capital and operation and maintenance costs for combined sewer overflow (Category V) and for urban stormwater runoff (Category VI).

PROGRAM OUTLINE

The program consists of two major parts. Part I computes both Category V and Category VI needs for the 320 Urbanized Areas based on the Urbanized Area data base, and Part II computes additional Category V needs for combined sewer systems located outside of Urbanized Areas, based on the non-Urbanized Area data base. A complete Fortran listing of the Needs Estimating Computer Program is presented in Appendix D.

The major computational steps required to develop the necessary Urbanized Area cost estimates are outlined below.

1. Read in Urbanized Area (UA) data.
2. Compute UA characteristics (present condition).
    a. Stormwater area.
    b. Population density CSO.
    c. Population density SWR.
    d. Imperviousness CSO.
    e. Imperviousness SWR.
    f. Runoff coefficient CSO.
    g. Runoff coefficient SWR.
    h. Miles of streets CSO.
    i. Miles of streets SWR.
3. Compute annual pollutant loads (BOD_5 & SS).
    a. CSO.
    b. SWR.

   c. Wastewater treatment plant effluent.
   d. Background upstream flow.

4. Compute total annual water yield (CFS).
   a. CSO.
   b. SWR.
   c. Wastewater treatment plant effluent.
   d. Upstream flow (given).
5. Compute aesthetics objective needs.
   a. Category V.
   b. Category VI.
6. Compute removal requirements for fish and wildlife objective for both SS and BOD_5.
7. Compute removal obtained from aesthetics objective for both SS and BOD_5.
8. Determine optimum mix of pollutant removal, by sewer system type, to meet the fish and wildlife objective.
   a. Removal required for BOD, CSO.
   b. Removal required for SS, CSO.
   c. Removal required for BOD, SWR.
   d. Removal required for SS, SWR.
9. Determine level of effort for management practices.
   a. Streetsweeping--BOD, CSO.
   b. Streetsweeping--SS, CSO.
   c. Streetsweeping--BOD, SWR.
   d. Streetsweeping--SS, SWR.
   e. Sewer flushing-BOD, CSO.
   f. Sewer flushing--SS, CSO.
10. Determine costs for and removals obtained by management practices defined in Step 9.

11. Determine removal requirements for storage/treatment systems to meet the fish and wildlife objective.

    a. Storage/treatment removal for BOD, CSO.

    b. Storage/treatment removal for SS, CSO.

    c. Storage/treatment removal for BOD, SWR.

    d. Storage/treatment removal for SS, SWR.

12. Determine optimum treatment level, removal efficiency, and annual pollutant capture required for each storage/treatment system defined in Step 11.

13. Compute the optimum (minimum annual cost) storage/treatment combination for each storage/treatment system defined in Step 11.

14. Compute total capital and O&M costs, by sewer system type and pollutant, for optimum storage/treatment combinations.

    a. Costs for BOD removal from CSO.

    b. Costs for SS removal from CSO.

    c. Costs for BOD removal from SWR.

    d. Costs for SS removal from SWR.

15. Determine which pollutant controls costs (i.e., requires the highest or most costly level of control) and establish needs for the fish and wildlife objective based on removal of the controlling pollutant.

16. Compute storage volume and treatment rate required for two overflow events per year.

17. Scale up facilities identified in fish and wildlife objective to meet the two overflow event per year (recreation objective) criteria.

18. Compute capital and O&M costs for scaled-up facilities.

19. Compute cost of sewer separation in combined sewer portion of UA.

20. Print out results of computations.

21. Compute UA characteristics for future (year 2000) conditions and go to Step 3.

22. Repeat Steps 1 through 21 until needs for all 320 UA's have been computed.

A similar computational procedure is used to estimate combined sewer control needs in the non-Urbanized Areas. These computations are, however, less comprehensive since only Category V needs are considered. The remainder of this chapter describes the individual computational sequences and assumptions used in the needs computations.

URBANIZED AREA CHARACTERISTICS

The stormwater runoff area and population densities are straightforward computations based on the input data. Imperviousness is computed by the Stankowski equation[1], which relates watershed imperviousness to population density. The runoff coefficient for each portion of the Urbanized Area is computed based on the computed imperviousness and on the natural runoff coefficient. A runoff coefficient of 0.90 is assumed for impervious areas. Total miles of streets in the Urbanized Area is based on a relationship between total population and street miles presented in the *Areawide Assessment Manual*.[2]

ANNUAL POLLUTANT LOADS

Annual pollutant loads for BOD_5 and SS from combined sewer systems and urban stormwater runoff were computed using loading functions developed by Heaney et al.[3] These functions relate annual watershed pollutant yield to annual rainfall and population density. Wastewater treatment plant effluent pollutant loads for BOD_5 and SS were estimated by assuming an effluent quality of 30 mg/l (secondary treatment) and a flow of 100 gallons per person per day.

AESTHETICS OBJECTIVE NEEDS

The aesthetics objective needs estimates are based on a uniform technology which is applied nationwide. This level of control is designed to provide a minimum level for CSO treatment, which will result in the removal of a significant portion of the annual solids presently discharged to receiving waters and will provide certain minimum management practices for urban stormwater runoff.

Aesthetics objective needs for Category V are based on providing an optimum mix of management practices in combined sewer watersheds. Cost estimates are based on sweeping all streets once every 4 days ($X_{sw} = 0.25$) and on flushing 13% of the sewers daily ($X_{sf} = 0.13$). It is assumed that all streets in combined sewer service areas are constructed with curb and gutter sections. This combination of management practices should remove approximately the same amount of combined sewer solids as the swirl concentrator/screening system used as a basis for estimating Category V aesthetics objective needs in the 1976 needs survey.

Aesthetics objective needs for Category VI in existing urban areas are based on providing streetsweeping of all streets with curb and gutter sections swept once every 10 days ($X_{sw} = 0.1$) and on providing erosion control in all areas experiencing active construction. It is assumed that one half of all streets in existing stormwater areas are constructed with curb and gutter sections and that 4% of the urban area will experience active construction in any given year. In addition, for new urban areas which will develop between the present time and the year 2000, it is assumed that earthen stormwater detention basins will be incorporated into the new construction. These detention basins will be sized to provide detention storage for 90% of the annual runoff.

POLLUTANT REMOVAL REQUIREMENTS FOR FISH AND WILDLIFE OBJECTIVE

Computation of suspended solids removal requirements to meet the fish and wildlife receiving water quality objective is accomplished by application of equation 10-1.

Computation of BOD_5 removal requirements is somewhat more involved. Computations begin by computing the total number of hours per year that the receiving water experiences DO levels less than 2.0 mg/l. This estimate is obtained by application of equation 10-10. If the total number of hours per year below 2.0 mg/l (VT) is less then 4.0, then BOD removal is not required. If VT is greater than 4.0 hours per year, then VT is recomputed based on removal of all of the BOD_5 load from CSO and SWR. If VT is still greater than 4.0 hours per year, then the receiving water DO problem cannot be solved by removal of pollutants from CSO and SWR alone and BOD_5 removal requirements are set equal to 90%. If the recomputed VT is less than 4.0 hours per year, then exact BOD removal requirements are obtained by interpolation.

OPTIMUM MIX OF POLLUTANT
REMOVAL BY SEWER SYSTEM TYPE

An estimate of the optimum mix of pollutant removal by sewer system type is obtained by first computing the removal required from the stormwater portion of the urban area (REMSWR) using equation 10-11. The remaining required pollutant removal is then obtained from the combined sewer watershed.

MANAGEMENT PRACTICES

Once removal requirements by pollutant and sewer system type are established, the level of effort, pollutant removal, and costs for streetsweeping and sewer flushing are estimated. The appropriate level of effort is estimated by the pollutant removal versus level of effort relationships presented in Figures 10-1, 10-2 and 10-3. Pollutant removals for each management practice considered are determined by application of the production functions defined on Figures 6-3 and 6-4 and by application of equations 6-6 and 6-9. Streetsweeping costs are based on a unit cost of \$10.00 per curb mile swept and sewer flushing costs are based on a unit capital cost of \$9,000 per sewer flushing station and a unit O&M cost of \$1,630 per station per year. A complete sewer flushing network is assumed to require a sewer flushing station density of one station every 2-1/4 acres.[2]

Streetsweepers are assumed to have an economic life of 5 years and sewer flushing stations are assumed to have an economic life of 10 years. The needs estimates are developed for a 20-year planning period. Therefore, the present worth of anticipated capital replacements during the planning period is also included.

STORAGE/TREATMENT SYSTEMS

If total required pollutant removals are less than approximately 30%, then storage/treatment systems are generally not required. That is, the total required pollutant removal can be obtained by application of optimum management practices. Given an estimate of the pollutant removal obtained by management practices, the additional removal required from storage/treatment systems, if any, is obtained by application of equation 10-13.

Once removal requirements are established, an appropriate treatment level is selected (see Table 10-3) and the required annual pollutant capture is computed. The optimum combination of storage volume and treatment rate is then determined by application of the storage/treatment isoquants presented in Chapter 6. The basis of this computation is the isoquant equation (equation 6-1) transformed as given below.

$$S = \frac{\ln\left(\dfrac{T_2 - T_1}{T - T_1}\right)}{K} \qquad (12\text{-}1)$$

where

S = Storage volume in inches.

T_1 = Treatment rate, in inches per hour, at which isoquant becomes parallel to the ordinate.

T_2 = Treatment rate, in inches per hour, at which isoquant intersects the abscissa.

T = Treatment rate, in inches per hour.

K = Constant, in inches[1], which is a function of the required capture (C) and the rainfall region (See equation 6-4 and Table 6-1).

Equation 12-1 is defined graphically on Figure 12-1. The technically feasible range of solutions lies between storage = 0.0 and storage = S_{max} and between Treatment = T_1 and Treatment = T_2, as shown on Figure 12-1. The objective of the economic optimization is to identify that combination of storage volume and treatment rate which will minimize the total annual cost of the storage/treatment system considering both capital and O&M costs. The economic optimization consists of a pattern search of the technically feasible range.

Computations begin by computing ΔT, which is equal to $(T_2-T_1)/100$ or 0.001 inch per hour which ever is less and setting T equal to $T_1 + \Delta T$. The value of storage, S, corresponding to the treatment rate, T, is then computed by application of equation 12-1. The total equivalent annual cost of this combination of storage volume and treatment rate is then computed and saved. These computations are based on the capital and operation and maintenance cost relationships presented in Chapter 4.

Next, the treatment rate, T, is increased by ΔT and the storage volume and equivalent annual costs are recomputed. If the annual cost of the present storage/treatment combination is less than the annual cost of the previous storage/treatment combination, then the treatment rate, T, is again increased by an amount equal to ΔT and the process is repeated. When a storage/treatment combination is found which has an equivalent annual cost greater than the previous combination, then computations are complete and the optimum storage volume/treatment rate combination is set equal to the immediately preceding combination.

This storage/treatment cost minimization together with the use of appropriate management practices is the basis of the economic optimization of facility needs to meet the fish and wildlife water quality objective.

RECREATION OBJECTIVE

Needs for the recreation objective are based on treatment and disinfection of nearly all combined sewer overflow and urban stormwater runoff in order to eliminate bacterial contamination from these sources. An allowable discharge of two untreated overflow events per year has been selected as the basis for estimating facility needs.

Facilities requirements are based on the treatment level identified in the fish and wildlife objective except that a minimum treatment (Level 2) is specified. These facilities are scaled up, if necessary, in order to achieve the two overflow events per year criteria. Storage required to achieve this objective is estimated as follows.

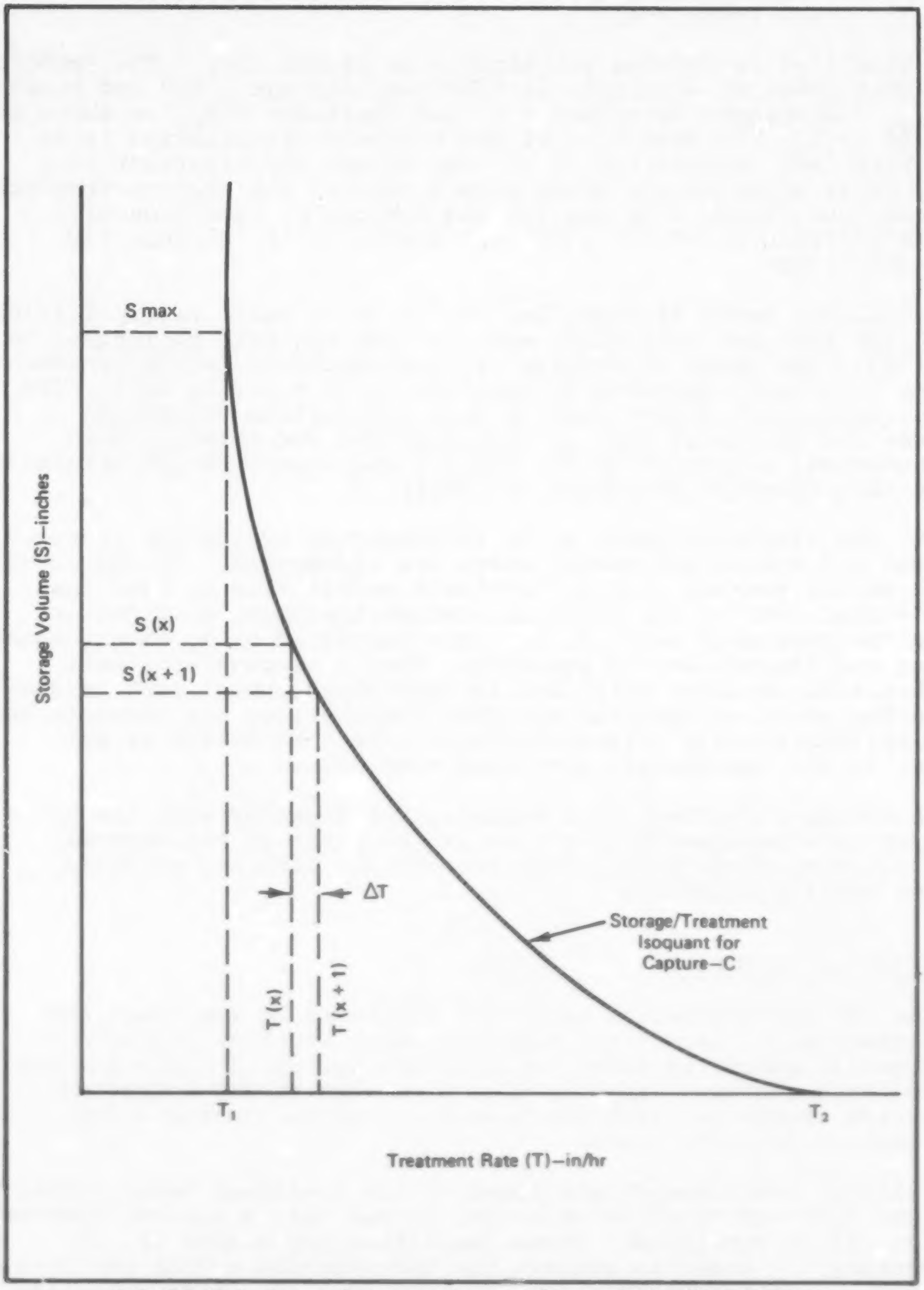


FIGURE 12-1. Storage/treatment isoquant for required pollutant capture.

$S_2 = 0.0653*AR-0.0273*ARD$ (12-2)

Where:

S_2 = Storage volume, in inches, required to obtain a maximum of two untreated overflow events per year.

AR = Annual runoff in inches.

ARD = Annual duration of runoff in percent of time, (i.e., ARD = 10 corresponds to runoff occurring 876 hours per year).

The above equation was developed by regression analysis of data developed in the 14 site studies. A total of 22 observations were used and the resulting correlation coefficient and standard error are 0.91 and 0.27 inches, respectively.

The ratio of S_2 to the storage required to meet the fish and wildlife objective is used as a scaling factor to obtain the facility sizes (both storage and treatment) required to meet the recreation objective. The costs of these scaled-up facilities are then computed.

YEAR 2000 CONDITIONS

Needs estimates for the year 2000 are based on the assumption that no new combined sewer systems will be constructed and that all population growth will occur in the separate sewer service area. Therefore, year 2000 Category V needs are equal to present Category V needs.

It is further assumed that existing population densities will remain constant and that new growth will be accommodated by an increase in urbanized land area and not by an increase in population density. Based on these assumptions, Urbanized Area characteristics in the year 2000 are computed and a needs estimate for these conditions is developed.

REFERENCES

1. Stankowski, S. J. Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization Special Report 38. U.S. Geological Survey, Water Resources Division. Trenton, NJ. 1974.

2. Areawide Assessment Procedures Manual--Volume III. EPA 600/9-70-014. July 1976.

3. Heaney, J. P. et al. Stormwater Management Model Level I--Preliminary Screening Procedures. EPA-600/2-76-275. October 1976.

Chapter 13
NEEDS FOR CONTROL OF COMBINED SEWER OVERFLOW

Tables 13-1, 13-2, and 13-3 present the estimated needs, by State, to meet the aesthetics water quality goal, the fish and wildlife water quality goal, and the recreation water quality goal, respectively. All costs are reported in millions of January 1978 dollars.

The first column of each table contains the estimated needs for Urbanized Areas within each State and the second column contains the estimated needs for non-Urbanized Areas. Needs met before January 1978 (column 3) were obtained from a recent report to Congress on combined sewer overflow control. These values are based on information contained in the Grants Information Control System (GICS) file and 75% grant eligibility. Column 4, Total Estimated Needs, is computed as column 1 plus column 2 minus column 3.

Each State's percentage of total national needs is reported in column 5 and annual operation and maintenance costs are reported in the last column. These O&M costs include both Urbanized Area and non-Urbanized Area needs.

Nationwide Category V needs developed in the 1978 Needs Estimate are compared to Category V needs developed in the 1976 Needs Estimate in the following table. Costs are reported in billions of January 1978 dollars.

Category V Needs

Needs Survey	Aesthetics Objective	Fish and Wildlife Objective	Recreation Objective
1976	6.5	14.0	21.2
1978	2.0	10.9	25.7

The 1978 estimated cost to achieve the aesthetics objective for Category V is lower than the 1976 estimated cost. The decrease is explained by alternative technology. In the 1976

Table 13-1
State Category V (Combined Sewer) Needs to
Achieve the Aesthetics Water Quality Goal

State	Current and Year 2000 Capital Costs ($$10^6$ January 1978)					
	Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Alabama	0.0	0.0	0.0	0.0	0.0	0.0
Alaska	0.0	0.394	0.005	0.389	0.02	0.096
Arizona	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	0.0	0.0	10.347	0.0	0.0	0.0
California	48.144	3.234	125.000	0.0	0.0	8.329
Colorado	0.382	0.976	7.031	0.0	0.0	0.216
Connecticut	17.737	5.879	4.131	19.485	0.97	3.493
Delaware	8.449	1.863	2.384	7.928	0.39	1.361
Dist. of Columbia	16.346	0.0	0.847	15.499	0.77	3.094
Florida	0.0	0.603	0.0	0.603	0.03	0.104
Georgia	21.089	0.344	0.0	21.433	1.06	2.661
Hawaii	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	0.0	9.733	0.0	9.733	0.48	1.110
Illinois	362.974	91.830	870.991	0.0	0.0	64.619
Indiana	230.757	87.926	44.621	274.062	13.58	37.560
Iowa	3.606	15.115	2.104	16.617	0.82	2.853
Kansas	29.160	0.455	0.0	29.615	1.47	4.081
Kentucky	37.041	16.946	0.0	53.987	2.68	7.565
Louisiana	0.0	0.0	0.0	0.0	0.0	0.0
Maine	17.798	41.085	0.0	58.883	2.92	7.177
Maryland	0.0	10.325	2.004	8.321	0.41	1.186
Massachusetts	73.577	7.328	32.420	48.485	2.40	14.627
Michigan	251.954	26.975	250.456	28.473	1.41	34.722
Minnesota	27.634	5.689	0.093	33.230	1.65	4.112
Mississippi	0.0	1.829	0.0	1.829	0.09	0.282

Table 13-1--Continued

State	Current and Year 2000 Capital Costs ($\$10^6$ January 1978) Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Missouri	95.177	2.547	0.163	97.561	4.84	13.219
Montana	0.0	7.181	0.0	7.181	0.36	1.066
Nebraska	21.463	0.281	0.0	21.744	1.08	2.623
Nevada	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	10.641	4.121	7.291	7.471	0.37	2.444
New Jersey	92.686	7.388	8.656	91.418	4.53	17.179
New Mexico	0.0	0.0	0.0	0.0	0.0	0.0
New York	318.658	27.623	16.367	329.914	16.34	71.850
North Carolina	6.300	0.397	0.0	6.697	0.33	0.743
North Dakota	1.035	0.969	0.0	2.004	0.10	0.318
Ohio	220.413	128.344	7.601	341.156	16.90	43.656
Oklahoma	0.0	0.0	0.0	0.0	0.0	0.0
Oregon	20.307	10.209	0.0	30.516	1.51	4.355
Pennsylvania	194.816	25.099	0.048	219.867	10.89	34.943
Rhode Island	13.928	13.957	16.164	11.721	0.58	4.065
South Carolina	0.0	0.0	0.0	0.0	0.0	0.0
South Dakota	0.214	2.366	1.873	0.707	0.04	0.406
Tennessee	11.622	5.537	0.0	17.159	0.85	2.053
Texas	4.126	0.0	0.0	4.126	0.20	0.492
Utah	0.0	0.300	0.0	0.300	0.01	0.077
Vermont	0.0	12.952	6.711	6.241	0.31	1.696
Virginia	22.458	2.815	4.129	21.144	1.05	3.857
Washington	68.154	18.064	0.791	85.427	4.23	10.257
West Virginia	27.398	36.313	0.384	63.327	3.14	7.933
Wisconsin	27.964	6.657	12.561	22.060	1.09	5.212
Wyoming	0.0	0.848	0.0	0.848	0.04	0.155

Table 13-1--Continued

	Current and Year 2000 Capital Costs ($\$10^6$ January 1978)					
State	Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Am. Samoa	0.0	0.0	0.0	0.0	0.0	0.0
Guam	0.0	0.0	0.0	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0	0.0	0.0	0.0
Puerto Rico	1.478	0.0	0.0	1.478	0.07	0.214
Trust Terr.	0.0	0.0	0.0	0.0	0.0	0.0
Virgin Islands	0.0	0.0	0.0	0.0	0.0	0.0
Totals	2,304.503	642.495	1,435.172	2,018.639	100.0	428.063

Table 13-2
State Category V (Combined Sewer) Needs to
Achieve the Fish and Wildlife Water Quality Goal

	Current and Year 2000 Capital Costs ($10^6 January 1978)					
State	Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Alabama	0.0	0.0	0.0	0.0	0.0	0.0
Alaska	0.0	3.045	0.005	3.040	0.03	0.188
Arizona	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	0.0	0.0	10.347	0.0	0.0	0.0
California	201.595	17.813	125.000	94.408	0.86	5.038
Colorado	2.798	4.953	7.031	0.720	0.007	0.212
Connecticut	133.902	50.317	4.131	180.088	1.65	5.032
Delaware	44.599	18.713	2.384	60.928	0.56	1.581
Dist. of Columbia	90.143	0.0	0.847	89.296	0.82	2.306
Florida	0.0	4.840	0.0	4.840	0.04	0.095
Georgia	119.162	3.137	0.0	122.299	1.12	2.722
Hawaii	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	0.0	57.808	0.0	57.808	0.53	1.763
Illinois	867.226	548.608	870.991	544.843	4.99	45.852
Indiana	611.872	550.189	44.621	1117.440	10.23	36.612
Iowa	20.515	79.664	2.104	98.075	0.90	3.149
Kansas	41.097	3.005	0.0	44.102	0.40	3.118
Kentucky	196.181	125.056	0.0	321.237	2.94	8.085
Louisiana	0.0	0.0	0.0	0.0	0.0	0.0
Maine	111.130	379.764	0.0	490.894	4.50	14.460
Maryland	0.0	81.093	2.004	79.089	0.72	2.211
Massachusetts	384.438	70.689	32.420	422.707	3.87	12.933
Michigan	564.611	192.418	250.456	506.573	4.64	25.274
Minnesota	115.034	42.351	0.093	157.292	1.44	4.339
Mississippi	0.0	15.335	0.0	15.335	0.14	0.365

Table 13-2--Continued

State	Current and Year 2000 Capital Costs ($\$10^6$ January 1978)				Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
	Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)		
Missouri	219.488	21.450	0.163	240.775	2.21	9.935
Montana	0.0	33.731	0.0	33.731	0.31	0.777
Nebraska	65.512	1.948	0.0	67.460	0.62	1.510
Nevada	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	75.768	53.018	7.291	121.495	1.11	4.335
New Jersey	455.153	43.055	8.656	489.552	4.48	13.674
New Mexico	0.0	0.0	0.0	0.0	0.0	0.0
New York	1,242.379	225.382	16.367	1,451.394	13.28	46.113
North Carolina	33.580	4.099	0.0	37.679	0.35	0.796
North Dakota	2.402	9.373	0.0	11.775	0.11	0.691
Ohio	639.429	659.169	7.601	1,290.997	11.82	40.637
Oklahoma	0.0	0.0	0.0	0.0	0.0	0.0
Oregon	98.257	88.394	0.0	186.651	1.71	5.789
Pennsylvania	817.544	270.541	0.048	1,088.037	9.96	30.265
Rhode Island	70.167	80.559	16.164	134.562	1.23	3.898
South Carolina	0.0	0.0	0.0	0.0	0.0	0.0
South Dakota	2.117	15.253	1.873	15.497	0.14	1.010
Tennessee	75.901	23.150	0.0	99.051	0.91	2.364
Texas	18.470	0.0	0.0	18.470	0.17	0.369
Utah	0.0	2.206	0.0	2.206	0.02	0.078
Vermont	0.0	127.066	6.711	120.355	1.10	4.129
Virginia	107.632	27.807	4.129	131.310	1.20	3.760
Washington	254.911	141.414	0.791	395.534	3.62	11.408
West Virginia	135.384	274.648	0.384	409.648	3.75	10.304
Wisconsin	125.258	39.950	12.561	152.647	1.40	4.791
Wyoming	0.0	3.341	0.0	3.341	0.03	0.132
Am. Samoa	0.0	0.0	0.0	0.0	0.0	0.0

Table 13-2--Continued

State	Current and Year 2000 Capital Costs ($\$10^6$ January 1978) Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Guam	0.0	0.0	0.0	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0	0.0	0.0	0.0
Puerto Rico	12.265	0.0	0.0	12.265	0.11	0.305
Trust Terr.	0.0	0.0	0.0	0.0	0.0	0.0
Virgin Islands	0.0	0.0	0.0	0.0	0.0	0.0
Totals	7,947.018	4,394.340	1,435.172	10,925.446	100.0	372.402

Table 13-3
State Category V (Combined Sewer) Needs to Achieve the Recreation Water Quality Goal

	Current and Year 2000 Capital Costs ($$10^6$ January 1978)					
State	Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Alabama	0.0	0.0	0.0	0.0	0.0	0.0
Alaska	0.0	9.170	0.005	9.165	0.04	0.262
Arizona	0.0	0.0	0.0	0.0	0.0	0.0
Arkansas	0.0	0.0	10.347	0.0	0.0	0.0
California	272.621	20.094	125.000	167.715	0.65	6.244
Colorado	2.797	4.895	7.031	0.661	0.003	0.186
Connecticut	286.918	116.125	4.131	398.912	1.55	10.190
Delaware	94.727	36.618	2.384	128.961	0.50	3.064
Dist. of Columbia	171.518	0.0	0.847	170.671	0.66	4.351
Florida	0.0	8.533	0.0	8.533	0.03	0.142
Georgia	212.465	6.267	0.0	218.732	0.85	4.573
Hawaii	0.0	0.0	0.0	0.0	0.0	0.0
Idaho	0.0	57.256	0.0	57.256	0.22	1.670
Illinois	2,001.532	1,001.189	870.991	2,131.730	8.28	75.127
Indiana	1,700.521	1,264.855	44.621	2,920.755	11.35	87.637
Iowa	43.827	151.162	2.104	192.885	0.75	5.233
Kansas	204.916	4.860	0.0	209.776	0.81	4.181
Kentucky	336.710	255.709	0.0	592.419	2.30	14.146
Louisiana	0.0	0.0	0.0	0.0	0.0	0.0
Maine	232.159	860.361	0.0	1,092.520	4.24	28.322
Maryland	0.0	149.135	2.004	147.131	0.57	3.568
Massachusetts	891.043	177.577	32.420	1,036.200	4.03	29.088
Michigan	1,483.897	368.850	250.456	1,602.291	6.22	53.707
Minnesota	133.438	53.869	0.093	187.214	0.73	4.807
Mississippi	0.0	33.286	0.0	33.286	0.13	0.696

Table 13-3--Continued

State	Current and Year 2000 Capital Costs ($\$10^6$ January 1978) Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Missouri	711.279	46.803	0.163	757.919	2.94	25.663
Montana	0.0	33.236	0.0	33.236	0.13	0.627
Nebraska	67.550	3.256	0.0	70.806	0.28	1.234
Nevada	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	150.927	129.360	7.291	272.996	1.06	7.754
New Jersey	899.402	119.017	8.656	1,009.763	3.92	27.804
New Mexico	0.0	0.0	0.0	0.0	0.0	0.0
New York	2,869.917	451.588	16.367	3,305.138	12.84	89.654
North Carolina	58.019	9.323	0.0	67.342	0.26	1.241
North Dakota	3.923	9.782	0.0	13.705	0.05	0.652
Ohio	1,773.078	1,496.137	7.601	3,261.614	12.67	94.095
Oklahoma	0.0	0.0	0.0	0.0	0.0	0.0
Oregon	236.474	194.859	0.0	431.333	1.68	12.206
Pennsylvania	1,625.883	572.271	0.048	2,198.106	8.54	54.307
Rhode Island	152.550	192.956	16.164	329.342	1.28	9.021
South Carolina	0.0	0.0	0.0	0.0	0.0	0.0
South Dakota	2.116	23.814	1.873	24.057	0.09	1.045
Tennessee	141.997	56.465	0.0	198.462	0.77	4.640
Texas	39.148	0.0	0.0	39.148	0.15	0.763
Utah	0.0	2.199	0.0	2.199	0.009	0.067
Vermont	0.0	215.692	6.711	208.981	0.81	5.683
virginia	226.122	50.818	4.129	272.811	1.06	6.656
Washington	437.018	457.091	0.791	893.318	3.47	25.891
West Virginia	259.797	494.788	0.384	754.201	2.93	16.939
Wisconsin	211.774	69.692	12.561	268.905	1.04	7.465
Wyoming	0.0	3.164	0.0	3.164	0.01	0.084
Am. Samoa	0.0	0.0	0.0	0.0	0.0	0.0

Table 13-3--Continued

	Current and Year 2000 Capital Costs ($\$10^6$ January 1978)					
State	Urbanized Area Needs (1)	Non-Urbanized Area Needs (2)	Needs Met Before 1978 (3)	Total Estimated Needs (4)	Percentage of National Needs (5)	Annual Operation and Maintenance Costs (6)
Guam	0.0	0.0	0.0	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0	0.0	0.0	0.0
Puerto Rico	19.360	0.0	0.0	19.360	0.08	0.441
Trust Terr	0.0	0.0	0.0	0.0	0.0	0.0
Virgin Islands	0.0	0.0	0.0	0.0	0.0	0.0
Totals	17,955.230	9,212.064	1,435.208	25,742.719	100.0	731.119

Needs Survey, aesthetics objective needs were based on providing swirl concentrators at all overflow points and consolidated screening of the concentrate. In the 1978 Needs Survey, aesthetics objective needs are based on providing an optimum mix of streetsweeping and combined sewer flushing. Both methods can remove approximately 40% of the combined sewer solids which are now discharged to the receiving water. However, the streetsweeping/ sewer flushing combination has an obvious cost advantage.

The 1978 estimated cost to achieve the fish and wildlife objective is also lower than the 1976 estimated cost. The major reason for the estimated decrease in fish and wildlife objective needs is the economic optimization analysis considered in the needs computations. This optimization results in the selection of the most cost-effective mix of technologies at a given site for a specified level of pollutant removal. The economic optimization of pollution control alternatives is a major enhancement of the 1978 needs estimate over the 1976 approach.

The 1978 estimated cost to achieve the recreation receiving water quality objective is higher for combined sewer overflow control than the 1976 estimated cost. The approximately 21% increase in estimated construction cost for Category V needs is due to two factors. First, identified combined sewer service area has increased from approximately 2-1/4 million acres in the 1976 Needs Survey to approximately 2-1/2 million acres in the 1978 Needs Survey. Second, a more accurate estimate of storage volume required to achieve the recreation receiving water quality goal was utilized in the 1978 needs computations. This technique yields slightly larger values for required storage volume.

In addition to the required Category V Needs Estimate for the three receiving water quality objectives discussed above, an estimate of nationwide capital cost of sewer separation has also been developed. This estimate is based on the sewer separation cost function presented in Chapter 4, the population served by each combined sewer system, and the citywide construction cost index. Estimated sewer separation capital cost for Urbanized Areas is 89.3 billion and for non-Urbanized areas is 14.6 billion, resulting in a total national cost estimate of $103.9 billion (January 1978).

Table 13-4 presents a summary by State of estimated capital cost of sewer separation. Also presented is a summary of known combined sewer service area and population served nationally. Combined sewers serve approximately 2-1/2 million acres and 40 million persons. Therefore, estimated Category V needs as reported to Congress (recreation level) are approximately $643 per person served.

Table 13-5 presents a summary of the unit cost of correction expressed in terms of dollars per acre for Category V. This summary is based on analysis of the results obtained from the 127 estimates developed for combined sewer systems located in Urbanized

Table 13-4
Summary of Combined Sewer Area, Population Served, and Estimated Cost of Sewer Separation by State

State	Combined Sewer Area (acres)	Population Served (1,000 persons)	Sewer Separation Cost (million dollars)
Alabama	0.0	0.0	0.0
Alaska	324.0	5.4	12.427
Arizona	0.0	0.0	0.0
Arkansas	0.0	0.0	0.0
California	38,100.0	852.1	2,436.760
Colorado	1,444.0	19.0	37.292
Connecticut	20,581.0	344.4	836.273
Delaware	8,451.0	90.1	236.701
District of Columbia	14,713.0	489.1	1,096.647
Florida	630.0	4.4	8.593
Georgia	25,083.0	221.7	411.343
Hawaii	0.0	0.0	0.0
Idaho	9,306.0	46.0	105.696
Illinois	365,422.0	5,693.6	15,254.740
Indiana	274,955.5	1,997.5	5,079.390
Iowa	21,215.0	396.4	736.482
Kansas	28,500.0	384.0	853.920
Kentucky	49,465.3	732.6	1,701.097
Louisiana	0.0	0.0	0.0
Maine	47,163.8	394.5	932.852
Maryland	10,105.0	53.9	120.824
Massachusetts	66,043.0	1,943.4	4,862.247
Michigan	260,961.0	2,506.5	5,817.527
Minnesota	30,768.0	269.5	638.422
Mississippi	1,570.0	19.1	46.759
Missouri	89,466.0	1,158.6	2,760.806
Montana	7,723.0	129.0	253.636
Nebraska	25,471.0	199.4	371.192
Nevada	0.0	0.0	0.0

Table 13-4--Continued

State	Combined Sewer Area (acres)	Population Served (1,000 persons)	Sewer Separation Cost (million dollars)
New Hampshire	12,266.0	278.5	695.132
New Jersey	67,088.7	1,822.5	5,469.801
New Mexico	0.0	0.0	0.0
New York	233,592.0	9,091.8	27,768.886
North Carolina	10,566.0	38.4	53.565
North Dakota	1,808.2	25.6	59.318
Ohio	324,913.7	3,159.5	7,385.218
Oklahoma	0.0	0.0	0.0
Oregon	28,275.0	436.3	1,002.285
Pennsylvania	189,919.9	4,030.6	9,934.732
Rhode Island	23,730.0	394.0	982.084
South Carolina	0.0	0.0	0.0
South Dakota	2,332.0	37.6	87.081
Tennessee	20,287.0	150.5	277.759
Texas	4,670.0	35.0	67.542
Utah	284.0	4.7	9.313
Vermont	11,187.0	123.1	307.347
Virginia	23,726.0	442.1	991.335
Washington	81,987.9	628.2	1,443.353
West Virginia	59,745.2	543.2	1,257.875
Wisconsin	30,921.3	557.3	1,304.578
Wyoming	877.0	14.7	28.799
Guam	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0
Puerto Rico	1,067.0	17.8	52.340
Virgin Islands	0.0	0.0	0.0
American Samoa	0.0	0.0	0.0
Pacific Trust	0.0	0.0	0.0
Total	2,526,704.5	39,781.4	103,927.745

Areas. The range of unit costs within any receiving water quality objective is large, indicating a dependence on site-specific variables which should be addressed in future facilities plans.

Table 13-5
Unit Capital Cost of Correction for Combined Sewer Systems Located in Urbanized Areas

Receiving Water Objective	Unit Cost ($/acre)		
	Mean	Maximum	Minimum
Aesthetics	1,184	1,699	630
Fish and wildlife	4,086	17,851	671
Recreation	9,221	35,131	2,680
Sewer separation	45,872	188,951	4,113

Table 13-6 is also based on analysis of the 127 Urbanized Area estimates and presents the degree of treatment selected for both the fish and wildlife and the recreation receiving water objectives. In terms of area served, treatment level 3 is selected most often and, in terms of population served, treatment level 4 is most often selected.

Table 13-7 presents a summary of storage, treatment, and management practices parameters selected for control of pollution from combined sewer overflow for Urbanized Areas. Parameters for both the fish and wildlife and recreation water quality objectives are presented. Storage volumes and treatment rates are given on a per acre and per capita basis as well as for Urbanized Area totals.

Table 13-6
Selected Treatment Levels for Combined Sewer Systems Located in Urbanized Areas

A) Fish and Wildlife Objective

Treatment Level	Capital Cost (million of 1978 $)	Area (acres)	Population
1. Storage + disinfection	29	36,410	385,000
2. 1 + Microscreen	38	31,781	235,184
3. 2 + Sedimentation-flocculation	2,639	817,148	9,302,403
4. 3 + High-rate filtration	2,209	534,465	12,814,696
5. 4 + Dissolved air flotation	3,041	527,362	10,978,767
Total	7,956	1,947,166	33,716,050

B) Recreation Objective

Treatment Level	Capital Cost (million of 1978 $)	Area (acres)	Population
1. Storage + disinfection	0	0	0
2. 1 + Microscreen	514	68,191	620,184
3. 2 + Sedimentation-flocculation	6,738	817,148	9,302,403
4. 3 + High Rate filtration	4,859	534,465	12,814,696
5. 4 + Dissolved air flotation	5,844	527,362	10,978,767
Total	17,955	1,947,166	33,716,050

Table 13-7
Parameter Summary for Combined Sewer Systems Located in Urbanized Areas

Parameter	Receiving Water Objective Fish and Wildlife	 Recreation
Total storage	20.6×10^9 gallons	62.2×10^9 gallons
Mean storage per acre	10,573 gallons	31,938 gallons
Mean storage per person served	618 gallons	1,844 gallons
Total treatment rate	4,109 mgd	13,743 mgd
Mean treatment rate per acre	2,110 gpd	7,059 gpd
Mean treatment rate per person served	123 gpd	408 gpd
Mean dewatering time of full storage facility (range)	5 (0.3 - 16) days	4.5 (1.5 - 16) days
Mean percentage of sewers flushed daily (range)	1.2 (0 - 10)	Not used
Mean percentage of streets swept daily (range)	6.6 (3 - 14)	Not used

Chapter 14
NEEDS FOR CONTROL OF URBAN STORMWATER RUNOFF

Tables 14-1, 14-2, and 14-3 represent the estimated needs, by State, to meet the aesthetics water quality goal, the fish and wildlife water quality goal, and the recreation water quality goal, respectively, for Category VI. All costs are reported in millions of January 1978 dollars.

The first column of each table presents an estimate of current capital needs, by State, and the second column presents an estimate of current annual O&M costs. The same information for year 2000 conditions is presented in columns 3 and 4, respectively. The percentable of national needs, by State, reported in column 5 is based on year 2000 capital needs.

The following table presents a comparison of nationwide Category VI needs developed in the 1978 Needs Estimate to Category VI needs developed in 1976. Costs are reported in billions of January 1978 dollars.

Category VI Needs (years 1990 and 2000)

Needs Survey	Aesthetics Objective	Fish and Wildlife Objective	Recreation Objective
1976 (1990)	23.7	58.7	62.8
1978 (2000)	1.4	29.2	61.7

The difference in aesthetics level needs is explained by differing assumptions related to the cost of storage of stormwater in newly developing areas. In the 1976 Needs Survey, the cost of storing stormwater runoff was assumed to be $0.50 per gallon, which is a trypical unit cost for concrete storage basins. In the 1978 Needs Survey, it was assumed that stormwater storage could be designed into new developments in such a manner that earthen detention basins would be utilized. A typical unit cost for this type facility is approximately $0.03 per gallon.

The 1978 estimated cost to achieve the fish and wildlife objective is also lower than the 1976 estimated cost for Category VI. The

Table 14-1
State Category VI (Stormwater) Needs to
Achieve the Aesthetics Water Quality Goal

State	Current and Year 2000 Capital and Operation and Maintenance Costs ($$10^6$ Jan 1978) Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Alabama	2.451	10.080	17.747	12.497	1.23
Alaska	0.247	0.927	6.811	3.306	0.47
Arizona	2.048	7.306	27.279	18.418	1.90
Arkansas	0.693	2.500	11.692	4.549	0.81
California	34.721	89.423	145.640	123.855	10.12
Colorado	2.547	7.148	18.958	13.196	1.32
Connecticut	4.441	15.496	21.867	17.233	1.52
Delaware	0.645	1.883	7.506	3.221	0.52
Dist. of Columbia	0.537	1.020	6.874	2.690	0.48
Florida	8.507	28.415	167.643	62.689	11.65
Georgia	2.839	9.819	28.591	15.448	1.98
Hawaii	1.514	3.901	12.283	7.424	0.85
Idaho	0.196	0.565	2.555	1.149	0.18
Illinois	6.745	22.856	44.757	32.126	3.11
Indiana	1.966	11.903	34.454	17.886	2.39
Iowa	1.234	5.573	8.272	6.932	0.57
Kansas	0.854	3.279	17.152	6.735	1.19
Kentucky	1.431	4.851	22.694	9.013	1.58
Louisiana	3.290	7.601	14.372	9.852	1.00
Maine	0.096	1.574	15.575	3.836	1.08
Maryland	5.168	12.067	23.491	16.423	1.63
Massachusetts	5.960	23.062	34.467	28.029	2.39
Michigan	7.351	21.931	27.606	26.153	1.92
Minnesota	3.671	13.863	18.594	17.375	1.29
Mississippi	0.769	2.621	5.778	3.569	0.40
Missouri	3.090	12.608	22.998	16.557	1.60

Table 14-1--Continued

State	Current and Year 2000 Capital and Operation and Maintenance Costs ($\$10^6$ Jan 1978)				Percent of National Needs (based on Year 2000 needs) (5)
	Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	
Montana	0.287	0.811	1.267	1.082	0.09
Nebraska	0.702	1.990	4.833	3.109	0.34
Nevada	0.877	3.295	10.938	7.661	0.76
New Hampshire	0.111	1.060	43.907	8.373	3.05
New Jersey	12.837	50.395	96.053	69.348	6.67
New Mexico	0.536	1.760	3.895	2.970	0.27
New York	15.929	29.483	45.872	37.361	3.19
North Carolina	1.796	6.446	12.906	7.997	0.90
North Dakota	0.110	0.285	0.612	0.408	0.04
Ohio	9.260	33.605	41.076	39.253	2.85
Oklahoma	1.706	7.112	13.276	10.150	0.92
Oregon	1.257	4.984	29.302	10.433	2.04
Pennsylvania	7.972	29.584	29.634	30.876	2.06
Rhode Island	1.252	3.889	1.183	3.673	0.08
South Carolina	0.963	3.429	6.158	4.279	0.43
South Dakota	0.201	0.547	1.147	0.773	0.08
Tennessee	2.638	10.647	25.717	14.684	1.79
Texas	11.917	43.039	180.774	92.238	12.56
Utah	1.331	4.647	6.248	5.554	0.43
Vermont	0.0	0.0	0.0	0.0	0.0
Virginia	4.084	14.887	51.732	24.819	3.59
Washington	3.140	11.058	28.062	16.349	1.95
West Virginia	0.368	1.688	2.390	2.011	0.17
Wisconsin	3.423	12.568	28.621	18.103	1.99
Wyoming	0.0	0.0	0.0	0.0	0.0
Am. Samoa	0.0	0.0	0.0	0.0	0.0
Guam	0.0	0.0	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0	0.0	0.0
Puerto Rico	2.886	5.218	8.192	6.514	0.57

Table 14-1--Continued

	Current and Year 2000 Capital and Operation and Maintenance Costs ($\$10^6$ Jan 1978)				
State	Current Capital Costs (Needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (Needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (Based on Year 2000 Needs) (5)
Trust Terr.	0.0	0.0	0.0	0.0	0.0
Virgin Islands	0.0	0.0	0.0	0.0	0.0
Totals	118.591	604.673	1,439.421	898.147	100.0

Table 14-2
State Category VI (Stormwater) Needs to
Achieve the Fish and Wildlife Water Quality Goal

	Current and Year 2000 Capital and Operation and Maintenance Costs ($$10^6$ Jan 1978)				
State	Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Alabama	338.977	15.035	463.447	18.137	1.58
Alaska	44.951	1.211	122.291	3.536	0.42
Arizona	236.388	7.862	533.396	18.962	1.83
Arkansas	49.455	2.704	78.900	4.436	0.27
California	2,367.056	99.440	3,097.444	133.283	10.61
Colorado	106.264	3.859	167.470	6.427	0.57
Connecticut	830.963	36.493	890.124	39.674	3.05
Delaware	70.698	2.717	104.913	4.246	0.36
Dist. of Columbia	61.247	2.246	133.840	5.258	0.46
Florida	1,563.531	73.221	2,936.213	149.565	10.06
Georgia	374.318	14.068	507.020	19.974	1.74
Hawaii	118.019	4.431	207.264	7.941	0.71
Idaho	17.088	0.535	29.404	0.921	0.10
Illinois	807.256	35.548	1,040.938	47.671	3.55
Indiana	538.015	22.266	723.954	30.444	2.47
Iowa	155.105	6.469	186.756	7.762	0.63
Kansas	61.598	3.034	58.756	3.274	0.20
Kentucky	298.770	11.315	463.548	20.185	1.59
Louisiana	290.535	12.565	346.025	15.492	1.18
Maine	105.871	3.997	173.990	7.623	0.60
Maryland	459.985	22.968	712.651	33.564	2.44
Massachusetts	1,034.546	48.556	1,184.454	57.285	4.06
Michigan	748.459	35.507	854.533	40.436	2.93
Minnesota	156.173	6.878	170.318	7.912	0.58
Mississippi	135.878	5.583	172.459	6.901	0.59
Missouri	345.607	16.457	370.971	18.082	1.27

Table 14-2--Continued

State	Current and Year 2000 Capital and Operation and Maintenance Costs ($\$10^6$ Jan 1978)				
	Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Montana	20.732	0.766	25.027	0.939	0.08
Nebraska	66.659	2.472	101.455	3.737	0.34
Nevada	113.444	3.302	218.450	6.685	0.74
New Hampshire	72.557	2.212	261.456	9.796	0.90
New Jersey	2,209.514	118.922	2,903.453	161.516	9.94
New Mexico	31.895	0.949	49.491	1.495	0.17
New York	1,036.408	46.308	1,077.743	50.876	3.68
North Carolina	212.904	8.082	243.363	9.492	0.83
North Dakota	3.909	0.238	4.665	0.259	0.02
Ohio	1,229.290	56.080	1,325.576	63.254	4.54
Oklahoma	78.020	4.050	103.740	5.458	0.35
Oregon	174.662	6.741	292.700	11.556	1.00
Pennsylvania	1,339.411	56.870	1,427.582	60.931	4.89
Rhode Island	130.358	5.392	125.434	5.153	0.43
South Carolina	156.164	5.850	188.139	6.993	0.64
South Dakota	6.829	0.409	9.704	0.552	0.03
Tennessee	219.729	9.427	285.652	12.516	0.97
Texas	977.996	39.678	1,655.497	70.141	5.66
Utah	106.357	2.994	109.520	33.719	0.37
Vermont	0.0	0.0	0.0	0.0	0.0
Virginia	762.898	29.842	1,301.172	53.582	4.55
Washington	532.531	23.259	721.799	32.866	2.46
West Virginia	110.279	4.032	119.593	4.489	0.41
Wisconsin	497.054	22.969	683.719	31.898	2.34
Wyoming	0.0	0.0	0.0	0.0	0.0
Am. Samoa	0.0	0.0	0.0	0.0	0.0
Guam	0.0	0.0	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0	0.0	0.0
Puerto Rico	201.448	8.805	235.595	10.438	0.81

Table 14-2--Continued

	Current and Year 2000 Capital and Operation and Maintenance Costs ($$10^6$ Jan 1978)				
State	Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Trust Terr.	0.0	0.0	0.0	0.0	0.0
Virgin Islands	0.0	0.0	0.0	0.0	0.0
Totals	21,657.272	954.584	29,201.031	1,326.948	100.0

Table 14-3
State Category VI (Stormwater) Needs to
Achieve the Recreation Water Quality Goal

	Current and Year 2000 Capital and Operation and Maintenance Costs ($$10^6$ Jan 1978)				
State	Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Alabama	1,212.966	60.651	1,428.370	72.067	2.32
Alaska	44.868	1.124	122.010	3.243	0.20
Arizona	235.560	7.039	531.491	16.976	0.86
Arkansas	373.717	24.760	610.525	43.828	0.99
California	3,113.770	113.060	4,047.876	150.273	6.56
Colorado	201.776	4.287	319.494	6.942	0.52
Connecticut	2,243.538	112.707	2,441.443	125.359	3.96
Delaware	178.336	5.573	270.383	8.994	0.44
Dist. of Columbia	84.195	3.029	184.561	7.204	0.30
Florida	3,542.938	197.566	6,909.125	432.440	11.20
Georgia	765.969	25.048	1,068.665	36.331	1.73
Hawaii	117.161	3.537	205.653	6.260	0.33
Idaho	24.133	0.562	41.671	0.965	0.07
Illianois	1,451.131	63.608	1,855.135	83.482	3.01
Indiana	1,353.832	79.354	1,633.752	71.151	2.65
Iowa	409.775	16.839	482.182	19.884	0.78
Kansas	228.488	9.996	418.709	19.182	0.68
Kentucky	529.855	23.854	925.625	46.943	1.50
Louisiana	781.714	31.881	940.536	40.136	1.53
Maine	267.647	9.904	679.106	36.309	1.10
Maryland	1,043.601	59.580	1,191.849	59.752	1.93
Massachusetts	2,772.137	139.765	3,205.351	164.810	5.20
Michigan	1,520.014	75.116	1,719.430	84.389	2.79
Minnesota	461.124	13.370	527.889	15.208	0.86
Mississippi	336.486	15.161	415.338	17.705	0.67
Missouri	1,062.430	59.819	1,172.799	57.693	1.90

Table 14-3--Continued

State	Current and Year 2000 Capital and Operation and Maintenance Costs ($\$10^6$ Jan 1978)				
	Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Montana	21.477	0.620	26.079	0.751	0.04
Nebraska	90.868	3.000	131.578	4.390	0.21
Nevada	113.089	2.932	217.645	5.845	0.35
New Hampshire	174.856	4.977	958.894	33.352	1.55
New Jersey	4,162.982	253.805	5,378.994	339.116	8.72
New Mexico	54.627	1.095	84.984	1.716	0.14
New York	1,877.500	83.603	2,026.998	91.370	3.29
North Carolina	649.000	28.023	777.296	35.732	1.26
North Dakota	9.326	0.302	16.779	0.382	0.03
Ohio	3,138.712	165.409	3,558.954	195.032	5.77
Oklahoma	310.045	13.810	411.963	18.859	0.67
Oregon	501.438	18.694	901.669	34.396	1.46
Pennsylvania	2,539.711	114.203	2,609.314	121.626	4.23
Rhode Island	360.938	12.641	347.016	12.042	0.56
South Carolina	334.259	12.897	379.781	13.653	0.62
South Dakota	21.783	0.756	30.032	1.045	0.05
Tennessee	988.997	35.842	1,313.997	52.052	2.13
Texas	2,164.211	84.473	3,773.298	147.811	6.12
Utah	154.516	3.256	171.921	3.641	0.28
Vermont	0.0	0.0	0.0	0.0	0.0
Virginia	1,222.888	45.940	1,975.668	84.633	3.20
Washington	1,031.828	50.071	1,374.248	70.073	2.23
West Virginia	189.302	6.649	220.100	8.125	0.36
Wisconsin	900.122	41.877	1,230.055	58.054	1.99
Wyoming	0.0	0.0	0.0	0.0	0.0
Am. Samoa	0.0	0.0	0.0	0.0.	0.0
Guam	0.0	0.0	0.0	0.0	0.0
Marianas Group	0.0	0.0	0.0	0.0	0.0
Puerto Rico	335.264	14.032	404.121	17.255	0.66

Table 14-3--Continued

State	Current and Year 2000 Capital and Operation and Maintenance Costs ($$10^6$ Jan 1978): Current Capital Costs (needs) (1)	Current Annual O&M Costs (2)	Year 2000 Capital Costs (needs) (3)	Year 2000 Annual O&M Costs (4)	Percent of National Needs (based on Year 2000 needs) (5)
Trust Terr.	0.0	0.0	0.0	0.0	0.0
Virgin Islands	0.0	0.0	0.0	0.0	0.0
Totals	45,704.344	2,156.061	61,670.352	2,978.445	100.00

major reason for the estimated decrease in fish and wildlife objective needs is the economic optimization analysis considered in the needs computations. This optimization results in the selection of the most cost-effective mix of technologies at a given site for a specified level of pollutant removal. The result is a lower needs estimate to achieve the fish and wildlife objective for both Categories V and VI.

The total estimated Category VI needs to achieve the recreation receiving water objective is nearly equal to the total reported in 1976.

Table 14-4 presents a summary of the unit cost of control expressed in terms of dollars per acre for Category VI. This summary is based on analysis of the results of the cost estimates developed for each of the 320 urbanized areas. The range of unit costs within any receiving water quality objective is large and generally shows greater variations than the unit costs for combined sewer overflow control.

Table 14-4
Unit Cost of Control for Urban Stormwater Runoff Based on Year 2000 Conditions

Receiving Water Objective	Unit Cost ($/acre) Mean	Maximum	Minimum
Aesthetics	45	168	2
Fish and wildlife	906	4,215	2
Recreation	1,913	6,914	379

Table 14-5 is also based on analysis of the 320 urbanized area estimates and presents the degree of treatment selected for both the fish and wildlife and the recreation receiving water objective. Of the five available treatment levels the two most often selected are level 2 and level 4. It is probable that level 2 is selected in cases where suspended solids removal controls the treatment requirements and that level 4 is selected in cases where BOD removal controls the treatment requirements. Level 5, which includes dissolved air flotation, was never selected for Category VI facilities.

Table 14-6 presents a summary of storage, treatment, and streetsweeping parameters selected for control of pollution from urban stormwater runoff for Urbanized Areas. Parameters for both the fish and wildlife and recreation water quality objectives are presented. Storage volumes and treatment rates are given on a per acre and per capita basis as well as for Urbanized Area totals.

Table 14-5
Selected Treatment Levels for Category VI (year 2000)

A) Fish and Wildlife Criteria

Treatment Level	Capital Cost (million of (1978 $)	Area (acres)	Population
1. Storage + disinfection	28	306,599	488,029
2. 1 + Microscreen	7,037	12,002,895	40,897,245
3. 2 + Sedimentation-flocculation	2,567	4,193,103	14,702,036
4. 3 + High-rate filtration	19,575	15,741,459	74,340,124
5. 4 + Dissolved air flotation	0	0	0
Total	29,207	32,244,056	130,427,434

B) Recreation Criteria

Treatment Level	Capital Cost (million of (1978 $)	Area (acres)	Population
1. Storage + disinfection	0	0	0
2. 1 + Microscreen	18,601	12,309,494	41,385,274
3. 2 + Sedimentation-flocculation	7,895	4,193,103	14,702,036
4. 3 + High Rate filtration	35,175	15,741,459	74,340,124
5. 4 + Dissolved air flotation	0	0	0
Total	61,670	32,244,056	130,427,434

Table 14-6
Parameter Summary for Control of Urban Stormwater Runoff in Urbanized Areas Based on Year 2000 Conditions

Parameter	Receiving Water Objective	
	Fish and Wildlife	Recreation
Total storage	273 x 10^9 gallons	797 x 10^9 gallons
Mean storage per acre	8,451 gallons	24,717 gallons
Mean storage per person served	2,089 gallons	6,110 gallons
Total treatment rate	42,119 mgd	132,864 mgd
Mean treatment rate per acre	1,306 gpd	4,121 gpd
Mean treatment rate per person served	323 gpd	1,019 gpd
Mean dewatering time of full storage facility (range)	6.5 (1.1 - 20) days	6 (2.3 - 20) days
Mean percentage of streets swept daily (range)	15.8 (5 - 21)	Not used

Chapter 15
SENSITIVITY AND CORRELATION ANALYSIS

INTRODUCTION

The purpose of this chapter is to identify sources of uncertainty in the methodology used to develop cost estimates for Categories V and VI and to quantify the sensitivity of the reported cost estimates to those uncertainties introduced by extrapolation from the detailed site studies.

Several sources of uncertainty exist in the Categories V and VI methodology: (1) the stochastic variation inherent in nature, (2) limited understanding of the causes and effects in physical and biological systems including toxicity and tolerance limits, (3) lack of nationally consistent data to quantify all input variables, and (4) limited full-scale operating experience with storm and combined sewer pollution abatement systems. The accuracy of the data contained in the combined sewer system data file described in Chapter 11 is no doubt a source of uncertainty in the needs estimate. However, it is the best information currently available and it is impossible to quantify the magnitude of error if any. Therefore, the following discussion will assume that the data contained in the 1978 combined sewer system data file are correct and that cost equations utilized in the needs estimate are also correct.

The sensitivity analysis was performed to quantify the uncertainty introduced into Categories V and VI cost estimates by extrapolation of results obtained from the detailed site studies and not to quantify uncertainty introduced by other sources.

SOURCES OF UNCERTAINTY

Aesthetics Cost Estimates

The estimated aesthetics costs for Category V are based on obtaining a fixed SS and BOD_5 removal of approximately 40% at all sites using a cost-effective mix of streetsweeping and sewer flushing. The aesthetics objective costs for Category VI in existing urban areas are based on sweeping all streets with curb and gutter sections once every 10 days ($X_{sw} = 0.10$) and providing erosion control in all areas experiencing active construction (for more details see Chapter 12). Since the method of calculating aesthetics control costs was fixed, no uncertainties were introduced by the methodology. The only uncertainties inherent in an aesthetics cost estimate relate to the cost and efficiencies of the technologies applied and these cannot be quantified. The aesthetics cost estimate is based on the best information available relevant to the cost and effectiveness of these control technologies.

Fish and Wildlife Cost Estimates

The estimated fish and wildlife costs for Categories V and VI are based on an empirical relationship developed from 14 receiving water impact studies, termed the "VT equation."

$$VT = 1012 + 864*DWQP + 256*WWQP - 204*DWDO \qquad (10\text{-}10)$$

where

VT = Total number of hours per year when the receiving water will experience dissolved oxygen levels less than 2.0 mg/l.

DWQP = Dry-weather quality parameter (See Chapter 10).

WWQP = Wet-weather quality parameter (See Chapter 10).

DWDO = Dissolved oxygen level occurring in the receiving water upstream from the urban area during the month of highest water temperature in mg/l.

The parameters of the VT equation are a function of the characteristics of the urban area receiving water system, and their evaluation requires knowledge of these characteristics including (1) the receiving water reaeration rate, (2) annual receiving water flow, (3) pollutant loads and flows generated by the urban area, (4) the annual duration of the waste loading events, (5) the waste decay rates of the various waste sources, and (6) the background receiving water quality including maximum temperature and background DO deficit. Each of these items along with the VT equation itself introduces some uncertainty into the estimation of needs.

Receiving water reaeration rates were reported on only 23 of the 1,241 combined sewer system worksheets obtained for the combined sewer system data file. Undoubtedly, the receiving water reaeration rates estimated from this limited data base and reported in Table 15-1 are a significant source of uncertainty. However, these receiving water reaeration rates are reasonable values and should yield usable results. A more site-specific approach to estimating the receiving water reaeration rate would improve future needs estimates for Categories V and VI.

For the most part, annual receiving water flows were taken from available USGS flow records. Uncertainties associated with these data are considered negligible.

Areawide receiving water pollutant loads were estimated using empirical relationships and available background water quality data. Receiving water loads from combined sewer overflow and urban stormwater runoff were calculated using equations

Table 15-1
Receiving Water Reaeration Rates

Class	Receiving Water Description	Estimated Reaeration Rate (day^{-1}) Base e at 20° C
1-5	Streams and rivers	$k_2 = 153.6(QUSF)^{(-0.588)}$ maximum = 10.2 minimum = 0.17
6	Impounded rivers	$k_2 = 0.10$
7	Small ponds, backwaters	N/A
8	Large lakes	N/A
9	Shallow, high-tidal-velocity estuary or bay	$k_2 = 0.96$
10	Shallow, low-tidal-velocity estuary or bay	$k_2 = 0.60$
11	Medium depth, high-tidal-velocity estuary or bay	$k_2 = 0.48$
12	Medium depth, low-tidal-velocity estuary or bay	$k_2 = 0.18$
13	Deep, high-tidal-velocity estuary or bay	$k_2 = 0.14$
14	Deep, low-tidal-velocity estuary or bay	$k_2 = 0.07$
15	Open ocean or beach	N/A

Note: QUSF = Mean annual upstream flow, in cfs.
N/A = Not applicable.

developed for a previous nationwide survey.[1] Data input for this calculation were the average annual rainfall and areawide population density, both of which should be known with certainty. The accuracy of these empirical equations is unknown. However, they are the best nationwide pollutant loading equations available to date.

The annual duration of runoff was estimated using data from the site studies. It was concluded that the average annual duration of runoff from a combined or separate sewered area could adequately be determined from the average annual number of days with rain, which is known. The uncertainty associated with the annual duration of runoff is therefore considered negligible.

Receiving water waste decay rates were assigned reasonable default values taken from the literature. First-order decay rates used in the 1978 needs survey are presented in Table 15-2.

Table 15-2
Receiving Water Decay Rates

Source	UOD Decay Rates (day^{-1}) Base e at 20° C
Combined sewer overflow	k_1 = 0.40
Stormwater runoff	k_1 = 0.16
Upstream flow	k_1 = 0.16
Wastewater treatment plant effluent	k_1 = 0.23

Actual receiving water waste decay rates have been known to vary substantially from the values given above, especially in small streams. However, site-specific data are nearly nonexistent.

The critical dry-weather DO deficit was calculated using Equation 15-1.

$$DWDO = DOSAT - 1.66 \qquad (15\text{-}1)$$

where

DOSAT = saturated dissolved oxygen concentration during the month of highest water temperature.

The constant term of 1.66 represents the average dry-weather DO deficit from the site studies.

It is apparent, from this discussion, that there are many sources of uncertainty in the approach developed to estimate Categories V and VI needs. However, when this approach is used nationwide, the overall uncertainty of the total Categories V and VI cost estimates is reduced since the residual sum of overestimating and underestimating site-specific parameters and resulting costs should approach zero. The uncertainty is greatest when considering a cost estimate for a single Urbanized Area, since it is possible for several parameters to be in error and for these errors to have a cumulative effect on the estimated needs.

Recreation Cost Estimates

The estimated recreation costs for Categories V and VI are based on an empirical relationship developed from the site studies, termed the "S_2 equation."

$$S_2 = 0.0653*AR - 0.0273*ARD \qquad (12\text{-}2)$$

where

S_2 = Storage volume, in inches, required to capture all but two untreated overflow events per year.

AR = Annual rainfall, in inches.

ARD = Annual duration of runoff, in percent of time.

The costs for facilities to meet the recreation objective were obtained by using the ratio of S_2 to the storage volume required to meet the fish and wildlife objective as a scaling factor applied to the previously determined storage/treatment system for fish and wildlife. The only source of uncertainty in the parameters of this relationship is the estimated annual duration of runoff, which was estimated based on the average annual number of days with rain. Thus the parameter uncertainty for the S_2 equation is considered negligible.

SENSITIVITY OF COST ESTIMATES

Fish and Wildlife Costs

The previous section indicates that the data used to calculate receiving water dissolved oxygen violations have many sources of uncertainty. If it were possible to eliminate the uncertainty in these data, each calculation of the dissolved oxygen violations would contain only the uncertainty introduced by the VT equation. Since the input data uncertainties cannot be quantified, a test of the fish and wildlife cost estimate sensitivity to the uncertainty of the VT equation must assume that the input data are correct. As discussed in Chapter 10, the VT equation has a standard error of 353 hours per year. The results of a sensitivity test indicate that the addition of 353 hours to all VT calculations increased the fish and wildlife total costs by 13.2% for Category V and 26.1% for Category VI. The subtraction of 353 hours from all VT calculations decreased the fish and wildlife total costs by 0.8% for Category V and 2.6% for Category VI.

Recreation Costs

The costs for facilities to meet the recreation objective were obtained by scaling up the fish and wildlife facilities to capture all but 2 overflow events per year. The scaling factor was determined by application of the S_2 equation. Again, it is assumed that the input data to these calculations were correct and that the only uncertainty was introduced by the S_2 equation. Based on the analysis presented in Chapter 10, the S_2 equation was found to have a standard error of 0.27 inches. The results of a sensitivity test indicate that the addition of 0.27 inches of storage to all calculations increased the recreation total costs by 16.9% for Category V and 18.3% for Category VI. The subtraction of 0.27 inches of storage from all calculations decreased the recreation total costs by 17.3% for Category V and 17.5% for Category VI.

CORRELATION ANALYSIS

A correlation analysis was performed on the Urbanized Area data in order to investigate the interrelationships between Urbanized Area characteristics and cost of pollution control for Categories V and VI for each receiving water objective. Two measures of costs were considered: (1) the total cost of control, and (2) the unit cost of control. The unit cost is expressed in dollars per acre, and total cost is in total dollars for the entire Urbanized Area.

Table 15-3 presents a summary of the independent Urbanized Area variables which were correlated against the cost data (the dependent variable). As noted in Table 15-3, some of these variables apply to Category V or Category VI only, whereas others apply to both categories.

Tables 15-4 and 15-5 present a summary of the correlation analyses for unit costs and total costs, respectively. The independent variables listed adjacent to each dependent variable are with the strongest correlation to the dependent variable. Six variables are listed in order of decreasing value of the correlation coefficient, which is also reported.

The results reported in Table 15-4 indicate that there is little strong correlation between unit cost of control and the independent Urbanized Area characteristics considered. The

Table 15-3
Correlation Analysis Independent Variable Definitions

Variable Name	Variable Definition	Relevant Category
CSAREA	Combined sewer area, in acres	5
CSPOP	Combined sewer population	5
SSAREA	Storm sewered area, in acres	6
SSPOP	Storm sewered population	6
UAPOP	Urbanized area population	5,6
UASZ	Urbanized area size, in square miles	5,6
NDR	Number of days with rain per year	5,6
RAIN	Mean annual rainfall, in inches	5,6
QUSF	Mean annual upstream flow of the receiving water, in cfs	5,6
PD	Percentage of the urbanized area draining to receiving water	5,6
T	Maximum monthly receiving water temperature °C	5,6
BOD	Background BOD concentration in the receiving water, in mg/l	5,6
SS	Background SS concentration in the receiving water, in mg/l	5,6
CNAT	Natural runoff coefficient for the urbanized area	5,6
VT	Total number of hours per year when the receiving water will experience dissolved oxygen levels less than 2.0 mg/l.	5,6
PD5	Population density of the combined sewer area, in persons/acre	5
PD6	Population density of the storm sewered area, in persons/acre	6

Table 15-4
Unit Cost Correlation Coefficients

Dependent Cost Variables	Independent Urbanized Area Variables 1st	2nd	3rd	4th	5th	6th
Category V Aesthetics level unit cost	UAPOP 0.466	PD5 0.456	CSPOP 0.443	VT 0.349	CNAT 0.299	UASZ 0.297
Category V Fish and wildlife level unit cost	PD5 0.271	RAIN 0.266	CNAT 0.210	VT 0.154	NDR 0.137	QUSF 0.055
Category V Recreation level unit cost	RAIN 0.481	CNAT 0.427	PD5 0.420	NDR 0.210	VT 0.149	QUSF 0.019
Category VI Aesthetics level unit cost	PD6 0.325	UAPOP 0.188	RAIN 0.157	SSPOP 0.150	VT 0.141	SS 0.067
Category VI Fish and wildlife level unit cost	NDR 0.370	CNAT 0.348	VT 0.264	PD 0.205	RAIN 0.202	PD6 0.199
Category VI Recreation level unit cost	CNAT 0.534	NDR 0.531	RAIN 0.521	PD6 0.150	QUSF 0.145	VT 0.141

Table 15-5
Total Cost Correlation Coefficients

Dependent Cost Variables	Independent Urbanized Area Variables					
	1st	2nd	3rd	4th	5th	6th
Category V Aesthetics level total cost	CSAREA 0.987	CSPOP 0.864	UAPOP 0.797	UASZ 0.628	VT 0.404	PD5 0.160
Category V Fish and wildlife level total cost	CSPOP 0.907	CSAREA 0.906	UAPOP 0.885	UASZ 0.714	VT 0.497	PD5 0.261
Category V Recreation level total cost	CSPOP 0.932	CSAREA 0.915	UAPOP 0.895	UASZ 0.658	VT 0.443	PD5 0.268
Category VI Aesthetics level total cost	SSAREA 0.935	SSPOP 0.798	UASZ 0.781	UAPOP 0.742	VT 0.348	PD6 0.136
Category VI Fish and wildlife level total cost	UASZ 0.872	SSAREA 0.823	SSPOP 0.698	UAPOP 0.693	VT 0.492	PD6 0.130
Category VI Recreation level total cost	UASZ 0.856	SSAREA 0.830	SSPOP 0.665	UAPOP 0.652	VT 0.433	CNAT 0.175

results reported in Table 15-5, on the other hand, indicate a strong correlation between total cost, area served, and population served. Based on these results, linear multiple regression analyses were run relating total cost (dependent variable) to area served and population served (independent variables). Both linear and logarithmic regression models were fit. The resulting best functions, their correlation coefficients, and standard error of estimate are reported in Table 15-6. These functions may be used to obtain a cursory or first-cut estimate of capital cost, in January 1978 dollars, to control pollution from combined sewer overflow and urban stormwater runoff for municipalities in the United States.

REFERENCES

1. Heaney, J. P. et al. "Nationwide Evaluation of Combined Sewer Overflows and Urban Stormwater Discharges, Volume II: Cost Assessments and Impacts." EPA-600/2-77-064, March 1977.

Table 15-6
Capital Cost Functions

Capital Cost	Cost Function	Correlation Coefficient	Standard Error of Estimate
Category V Aesthetics objective	$C = 1003\ A + 12\ P$	.998	$\$2.7(10)^6$
Category V Fish and wildlife objective	$C = 13123\ A^{.551}\ P^{.258}$	.962	$\$40(10)^6$
Category V Recreation objective	$C = 21363\ A^{.574}\ P^{.271}$	.971	$\$59(10)^6$
Category VI Aesthetics objective	$C = 40.5\ A + 1.0\ P$	.904	$\$3.0(10)^6$
Category VI Fish and wildlife objective	$C = 2314\ A^{.657}\ P^{.227}$	.812	$\$90(10)^6$
Category VI Recreation objective	$C = 13540\ A^{.807}\ P^{.021}$	.824	$\$160(10)^6$

Notes: A = Area served in acres, A = CSAREA for Category V cost functions and A = SSAREA for Category VI cost functions.
P = Population served, P = CSPOP for Category V cost functions and P = SSPOP for Category VI cost functions.
C = Estimated grant-eligible capital cost in January 1978 dollars and includes an allowance for planning and design.

APPENDIX A

SITE STUDY DATA

ROCHESTER, NEW YORK

DESCRIPTION OF STUDY SITE

The Rochester urban area is located along the Genessee River near the shore of Lake Ontario. A large urban area spans Monroe County in this area, so the study area was defined as the area tributary to the Genessee River between miles 12.0 and 4.5 above Lake Ontario. This area contains all significant combined sewer overflow locations to the Genessee River. Approximately 76% of the area tributary to the Genessee River is served by combined sewers. Much of the separate area drains to Irondequoit Creek.

The receiving water is the Genessee River beginning at the centroid of the urban area and extending to the mouth. Waste inputs from the urban area include combined sewer overflow, a small amount of urban runoff, and industrial wastewater treatment plant effluent. Effluent from the municipal wastewater treatment plant is discharged directly into Lake Ontario. Major characteristics of the study area and of the receiving water are presented in Table A-1. Pollutant loadings by source are summarized in Table A-2.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data on the Genessee River were provided by the United States Geological Survey (USGS) records. Additional water quality data for the river and for the wastewater treatment plant were obtained from the New York State Department of Environmental Conservation. Information on combined sewer overflow quantity and quality was obtained from the Rochester Pure Waters District. Additional data which were utilized to define urban area and receiving water characteristics of the Rochester study site were obtained from the following reports.

1. Wastewater Facilities Plan, Combined Sewer Overflow Abatement Program, Rochester Pure Waters District, Monroe County, New York. A joint venture by Erdman Anthony Associates; Lozier Engineers, Inc.; and Seelye, Stevenson, Value and Knecht, Inc. December 1976.

2. Lager, J. A., T. Didriksson, and G. B. Otte. "Development and Application of a Simplified Stormwater Management Model." EPA-600/2-76-218. August 1976.

3. Water Quality Management Plan for the Genessee River Basin. New York State Department of Environmental Conservation. November 1976.

CALIBRATION

The rainfall portion of the model was calibrated to known prototype conditions. The runoff and pollution washoff portions were adjusted to match overflow monitoring records collected by the City of Rochester. The dry-weather flow portion of the model was based on the permit requirements of the sole treatment plant which discharges into the study area. The upstream flow module was represented by actual observed streamflow records. The modeled dissolved oxygen distribution correlated well with observed data; however, continuous receiving water quality data are unavailable. Therefore, precise calibration of the receiving water response cannot be accomplished.

RESULTS

Simulation results indicate that removal of ultimate oxygen demand and suspended solids is required to meet the selected water quality criteria. Lead pollution from urban runoff was not determined to be a problem in Rochester. The removal requirements for the pollutants are summarized in Table A-3.

Table A-1
Major Characteristics
Rochester Site Study

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 3, 12	4, 5, 6, 7, 8, 9, 10, 11
Total seasonal rainfall (inches)	10.08	22.53
Mean time between storms (hours)	44.49	67.40
Mean duration of storm (hours)	9.6	7.1
Mean rainfall depth per event (inch)	0.0735	0.1597

Watershed Characteristics	Combined Sewer Watershed
Drainage area (acres)	11,476
Time of concentration (hours)	4
Washoff coefficient	4.6
Imperviousness (%)	50
Average annual runoff (inches)	5.06
BOD accumulation rate (lb/acre/day)	0.900
TKN accumulation rate (lb/acre/day)	0.0407
SS accumulation rate (lb/acre/day)	0.6775
Lead accumulation rate (lb/acre/day)	0.0003

Table A-1--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	55.8
Effluent limits (mg/l)	
BOD	18.95
SS	39.90
TKN	4.58
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	2,743
Mean K2 value (l/day base e)	0.17
Kl value for CSO (l/day base e)	0.40
Kl value for stormwater and upstream flow (l/day base e)	0.16
Kl value for WWTP effluent (l/day base e)	0.23
Maximum monthly temperature (°C)	23.5
Mean background BOD (mg/l)	3.0
Mean background SS (mg/l)	88
Background pH	7.9
Background hardness (mg/l)	125

Table A-2
Pollutant Loading Summary
Rochester Site Study

	Average Pollutant Loads (10^6 lb/yr)			
	BOD_5	TKN	SS	Pb
Upstream flow	14.8	3.6	476.7	0.054
WWTP effluent[a]	2.0	0.5	4.3	0.004
Combined sewer overflow	1.3	0.06	2.8	0.001
Urban stormwater runoff	--	--	--	--
Total	18.1	4.16	482.9	0.059

---

[a] Industrial waste only. WWTP effluent discharges directly to Lake Ontario.

Table A-3
Pollutant Removal Requirements
Rochester Site Study

	Percent Removal Requirements by Source	
Pollutant	Combined Sewer Overflow	Overall
Suspended solids	59	59
Ultimate oxygen demand (UOD)	89	89
Lead (Pb)	0	0

SYRACUSE, NEW YORK

DESCRIPTION OF STUDY SITE

Syracuse is located in central New York, about 35 miles southeast of Lake Ontario. Onondaga Creek, which flows north through Syracuse, is the principal drainage system for the urban area. The Syracuse urban area is served by combined sewers.

All drainage from Syracuse empties immediately into Lake Onandaga. Waste inputs to the lake include combined sewer overflow, urban stormwater runoff, and industrial and municipal wastewater treatment plant effluent. Major characteristics of the receiving water are presented in Table A-4. Pollutant loadings by source are summarized in Table A-5.

The continuous rainfall runoff water quality model (CSPSS) developed for this project does not apply in the case of Syracuse, where discharge is directly to a lake. That is, suspended solids and BOD removal requirements cannot be determined based on the selected criteria. However, the phosphorus criteria do apply and removal requirements for phosphorus have been determined.

SOURCES OF INFORMATION

Waste discharge monitoring information for 1970-1977 was obtained from Stearns and Wheeler Engineers, Cazenovia, New York. Water quality data were available for each source of pollution to Lake Onondaga.

RESULTS

The analysis indicates a mean lake phosphorus concentration of 0.36 mg/l. This represents a removal requirement of 93% of the phosphorus from influent sources. As shown in Table A-5, all sources of phosphorus influent to Lake Onondaga are severely in violation of the objective concentration of 0.025 mg/l. The largest contributor of phosphorus pollution is the Metropolitan Sewage Treatment Plant. This plant discharges 65% of the total phosphorus influent to the lake. If the phosphorus pollution from the treatment plant were completely removed, the remaining sources would require removal of 80% of the phosphorus to achieve the objective concentration of 0.025 mg/l.

It should be noted that backwater from the Seneca River has not been included in the analysis. In times of floods on the Seneca River, the flow commonly reverses and discharges into the lake. This occurrence dilutes the lake phosphorus concentrations. There are no records on the quantity or quality of this type of flow; therefore, detailed analysis cannot be attempted. Measurements at the lake outlet indicate a mean phosphorus concentration of 0.2 mg/l. This figure may be taken as the minimum possible lake concentration, as the outlet is surely the location of the lowest average concentration. Considering flushing from the Seneca River, the mean phosphorus concentration in the lake is between 0.2 and 0.36 mg/l, far from the goal of 0.025 mg/l.

Table A-4
Physical Characteristics of Lake Onondaga

Drainage area (mi^2)	285
Mean depth (meters)	13
Mean volume (ft^3)	5.7×10^9
Surface area (mi^2)	4.60

Principal Influent Streams

Stream	Drainage Area (mi^2)	Mean Discharge (ft^3/sec)
Nine Mile Creek	115	247
Ley Creek	29.9	102
Harbor Brook	11.3	18.2
Onondaga Creek	109	223

Table A-5
Average Waste Discharge to Lake Onondaga
Syracuse Site Study

Source	Annual Mass Loading Rate of Total Inorganic Phosphorus (lb/yr)	Average Concentration Total Inorganic Phosphorus (mg/l)
Ley Creek	48,600	0.24
Metropolitan Syracuse Sewage Treatment Plant	449,714	2.08
Onondaga Creek (receives CSO)	98,221	0.196
Harbor Brook	22,723	0.51
East Flume	26,142	0.14
Nine Mile Creek	45,347	0.094
Steel mill discharge	1,200	0.136
Total	691,947	0.42

PHILADELPHIA, PENNSYLVANIA

DESCRIPTION OF STUDY SITE

The City of Philadelphia is located in eastern Pennsylvania at the confluence of the Delaware and Schuylkill Rivers. The study area consists of the City of Philadelphia on the western bank of the Delaware River and Pennsauken, Camden, and the neighboring urban areas on the eastern bank of the river. This area is heavily industrialized and contains many industrial waste sources as well as numerous municipal wastewater treatment plants. Approximately 45% of the study area is served by combined sewers, and there are approximately 176 discrete combined sewer overflow points. The remainder is either drained naturally or is served by storm sewers.

The receiving water is the Delaware Estuary beginning just south of the City of Philadelphia and extending approximately 41 miles downstream. Waste inputs from the urban area include urban runoff, combined sewer overflow, and municipal and industrial wastewater effluents. Major characteristics of the study area and of the receiving water are presented in Table A-6. Pollutant loadings by source are summarized in Table A-7.

SOURCES OF INFORMATION

Rainfall and temperature data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data on the Delaware River/Estuary were provided by United States Geological Survey (USGS) records. Additional water quality data for the river as well as those pertaining to the collection system were obtained from the Philadelphia Water Department. The Delaware River Basin Commission supplied the effluent discharge and effluent quality data. Most of the physical data used to describe the Delaware Estuary, including hydraulic and dispersion data, were taken from the Thomann study referenced below. Additional data which were utilized to define urban area and receiving water characteristics of the Philadelphia study site were obtained from the following reports.

1. Watermation, Inc. Facility Plan, City of Philadelphia Combined Sewer Overflow Control. July 1976.

2. Thomann, R. V. Systems Analysis and Water Quality Management. Environmental Research and Applications, Inc. (now McGraw-Hill). 1972.

3. Philadelphia Water Department Research and Development Division. Urban Stormwater Quality/Land Use Characterization. November 1977.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records on the Delaware River and the Schuylkill River. The receiving water response module was calibrated for dissolved oxygen (DO) based on the continuous observed DO data in the Delaware Estuary at Chester, which is approximately 10 miles downstream of the Philadelphia Urbanized Area. The observed and simulated curves developed in this calibration are presented in Figure A-1.

RESULTS

Simulation results indicate that removal of ultimate oxygen demand (BOD and TKN) as well as suspended solids will be required to meet the selected water quality criteria. However, no lead removal is required. These removal requirements are summarized in Table A-8.

The Philadelphia study site has the most severe receiving water quality problems regarding DO concentrations of any of the 15 selected sites. The simulation results indicate that the removal of all oxygen-demanding pollutants from combined sewer overflow and urban stormwater runoff would still leave the receiving water with severe DO criteria violations. Thus, the DO criteria cannot be met by control of pollutants from CSO and urban runoff alone.

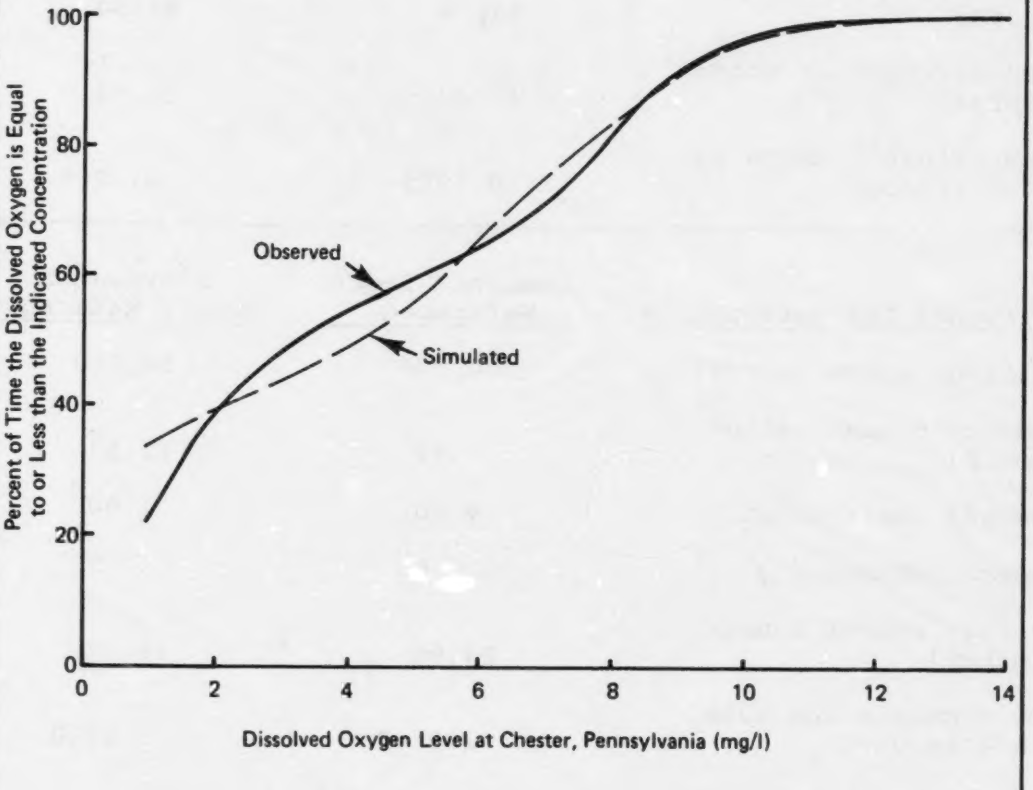


FIGURE A-1. Calibration of receiving water model at Philadelphia.

Table A-6
Major Characteristics
Philadelphia Site Study

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 9, 10, 11, 12	3, 4, 5, 6, 7, 8
Total seasonal rainfall (inches)	17.70	22.23
Mean time between storms (hours)	92.18	81.34
Mean duration of storm (hours)	42.42	39.52
Mean rainfall depth per event (inch)	0.2959	0.3206

Watershed Characteristics	Combined Sewer Watershed	Stormwater Runoff Watershed
Drainage areas (acres)	50,000	60,000
Time of concentration (hours)	5.42	12.53
Washoff coefficient	4.60	1.90
Imperviousness (%)	60	35
Average annual runoff (inches)	23.96	16.47
BOD accumulation rate (lb/acre/day)	2.0260	1.4940
TKN accumulation rate (lb/acre/day)	0.2309	0.4030
Suspended solids accumulation rate (lb/acre/day)	1.7700	1.3800
Lead accumulation rate (lb/acre/day)	0.0032	0.0032

Table A-6--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plants (ft^3/sec)	1,025.33
Effluent limits (mg/l)	
BOD	30.00
SS	30.00
TKN	12.17
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	16,312
Mean K2 value (l/day, base e)	0.10
Kl value for CSO (l/day, base e)	0.40
Kl value for stormwater and upstream flow (l/day, base e)	0.16
Kl value for WWTP effluent (l/day, base e)	0.23
Maximum monthly temperature (°C)	27.10
Mean background BOD (mg/l)	2.22
Mean background SS (mg/l)	34.0
Background pH	7.0
Background hardness (mg/l)	116.0

Table A-7
Pollutant Loading Summary
Philadelphia Site Study

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	70.10	20.13	1,043.10	0.4272
WWTP effluent	60.5	24.5	60.5	0.0807
Combined sewer overflow	20.8	2.369	31.86	0.0585
Urban stormwater runoff	11.981	3.235	30.235	0.0690
Total	163.381	50.234	1,165.695	0.6354

Table A-8
Pollutant Removal Requirements

Pollutant	Percent Removal Requirements by Source Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	72	78	75
Ultimate oxygen demand (UOD)	--	--	87[a]
Lead (Pb)	0	0	0

---

[a] This overall UOD removal will result in elimination of 90% of the DO occurrences less than 2.0 mg/l which can be eliminated by control of CSO and urban stormwater runoff.

WASHINGTON, DC

DESCRIPTION OF STUDY SITE

The Washington urban area is located in a large basin tributary to the Potomac River. The study area includes all of the Washington metropolitan area that is tributary to the Potomac River, from Cabin John Bridge to the Woodrow Wilson Memorial Bridge. Tributary areas in Virginia include Alexandria, Arlington, and Falls Church; and in Maryland, College Park, Cheverly, and parts of Rockville. The entire District of Columbia lies within the watershed. Approximately 6% of the study area is served by combined sewers. The remainder is either drained naturally or served by storm sewers.

The receiving water is the Potomac River Estuary beginning at the confluence of the Anacosta and Potomac Rivers and extending approximately 18 miles downstream. Waste inputs from the urban area include urban runoff, combined sewer overflow, and municipal wastewater treatment plant effluent. Major characteristics of the study area and of the receiving water are presented in Table A-9. Pollutant loadings by source are summarized in Table A-10.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality on the Potomac River were provided by the United States Geological Survey (USGS) records and the United States Environmental Protection Agency's STORET information retrieval system. Additional water quality data for the river and those data related to wastewater treatment plants were obtained from the Department of Water Resources of the Metropolitan Washington Council of Governments (COG) and from conversations with local treatment plant operators. COG publications and additional sources of information which were utilized to define urban area and receiving water characteristics of the Washington site study are listed below.

1. Water Resources Planning Board, Metropolitan Washington COG. *Major Sewage Treatment Plants in the Washington Metropolitan Area*. 1976.
2. _____. *The National Pollutant Discharge Elimination System*. 28 April 1977.
3. Thomann, R. V. *Systems Analysis and Water Quality Management*. McGraw Hill Book Co. pp. 184-186. 1972.

4. Hetling, L. J. and R. L. O'Connell. A Study of Tidal Dispersion in the Potomac River. Water Resources Research. Vol. 2, No. 4. 1966.

5. U.S. EPA, Office of Research and Development. Areawide Assessment Procedures Manual, Volume I. EPA-600/9-76-014. July 1976.

6. United States Soil Conservation Service. Hydrology--SCS National Engineering Handbook, Section 4. 1972.

7. USGS. Effects of Urban Development on Floods in Northern Virginia. Water Supply Paper 2001-C. 1970.

8. Hartigan, J. P., et al. Planning for Nonpoint Pollution Impacts. Presented at ASCE Urban Planning and Development Division Specialty Conference. Anaheim, California. 25-27 July 1977.

9. Linsley and Franzini. Water Resources Engineering, McGraw-Hill. 1972.

10. Metcalf & Eddy and Water Resources Engineers, Reconnaissance Study of Combined Sewer Overflows and Storm Sewer Discharges. Prepared for District of Columbia. March 1973.

11. Stearns and Wheeler. Infiltration/Inflow Analysis--Rock Creek Sewer System Drainage Basin. September 1976.

CALIBRATION

The rainfall and pollution washoff portions of the model were calibrated to known prototype conditions. Annual runoff volumes were estimated based on rainfall and percent impervious area, as described in Reference 5. The linear STORM model equation was assumed for the runoff coefficient determination. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records. Simulated receiving water dissolved oxygen concentrations were calibrated against DO measurements at Woodrow Wilson Bridge taken during 1965.[3] The simulated and observed cumulative frequency curves for 1965 conditions are shown on Figure A-2. The overall fit is fairly good; however, there are substantial deviations in the midrange. For the low DO concentrations of interest (i.e., less than 2.0 mg/l), the fit between observed and simulated is very good. Also shown on Figure A-2 are simulated conditions including the effects of the existing WWTP. These conditions are much improved over 1965 conditions.

RESULTS

Simulation results indicate that receiving water concentrations of dissolved oxygen, suspended solids, and long-term dissolved lead are in violation of the selected water quality criteria. The simulation also indicates that the water quality criteria for ultimate oxygen demand and suspended solids can be met by removal of these constituents from the rainfall-induced wastewater streams (CSO and urban runoff). These removal requirements are summarized in Table A-11.

Table A-9
Major Characteristics
Washington Site Study (Potomac River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 4, 10, 11	3, 5, 6, 7, 8, 9, 12
Total seasonal rainfall (inches)	18.42	21.65
Mean time between storms (hours)	95.35	94.76
Mean duration of storm (hours)	41.73	41.66
Mean rainfall depth per event (inch)	0.3471	0.3137

Watershed Characteristics	Combined Sewer Watershed	Stormwater Runoff Watershed
Drainage area (acres)	12,396	190,125
Time of concentration (hours)	1.2	5.00
Washoff coefficient	4.6	3.2
Imperviousness (%)	60	40
Average annual runoff (inches)	24.7	19.8
BOD accumulation rate (lb/acre/day)	2.4290	0.3800
TKN accumulation rate (lb/acre/day)	0.2094	0.0310
Suspended solids accumulation rate (lb/acre/day)	9.9200	2.0500
Lead accumulation rate (lb/acre/day)	0.0093	0.0044

Table A-9--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	758.72
Effluent limits (mg/l)	
BOD	6.30
SS	6.40
TKN	3.40
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	10,000
Mean K2 value (1/day base e)	0.30
Kl value for CSO (1/day base e)	0.40
Kl value for stormwater and upstream flow (1/day base e)	0.16
Kl value for WWTP effluent (1/day base e)	0.23
Maximum monthly temperature (°C)	26.0
Mean background BOD (mg/l)	2.1
Mean background SS (mg/l)	61
Background pH	8.2
Background hardness (mg/l)	110

Table A-10
Pollutant Loading Summary
Washington Site Study (Potomac River Basin)

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	48.43	13.01	1,535.98	1.891
WWTP effluent	9.26	5.00	9.41	0.059
Combined sewer overflow	6.50	0.56	44.22	0.041
Urban stormwater runoff	13.05	1.07	140.05	0.301
Total	77.24	19.64	1,729.66	2.292

Table A-11
Pollutant Removal Requirements
Washington Site Study (Potomac River Basin)

	Percent Removal Requirements by Source		
Pollutant	Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	91	64	70
Ultimate oxygen demand (UOD)	--	--	92
Lead (Pb)	--	--	100

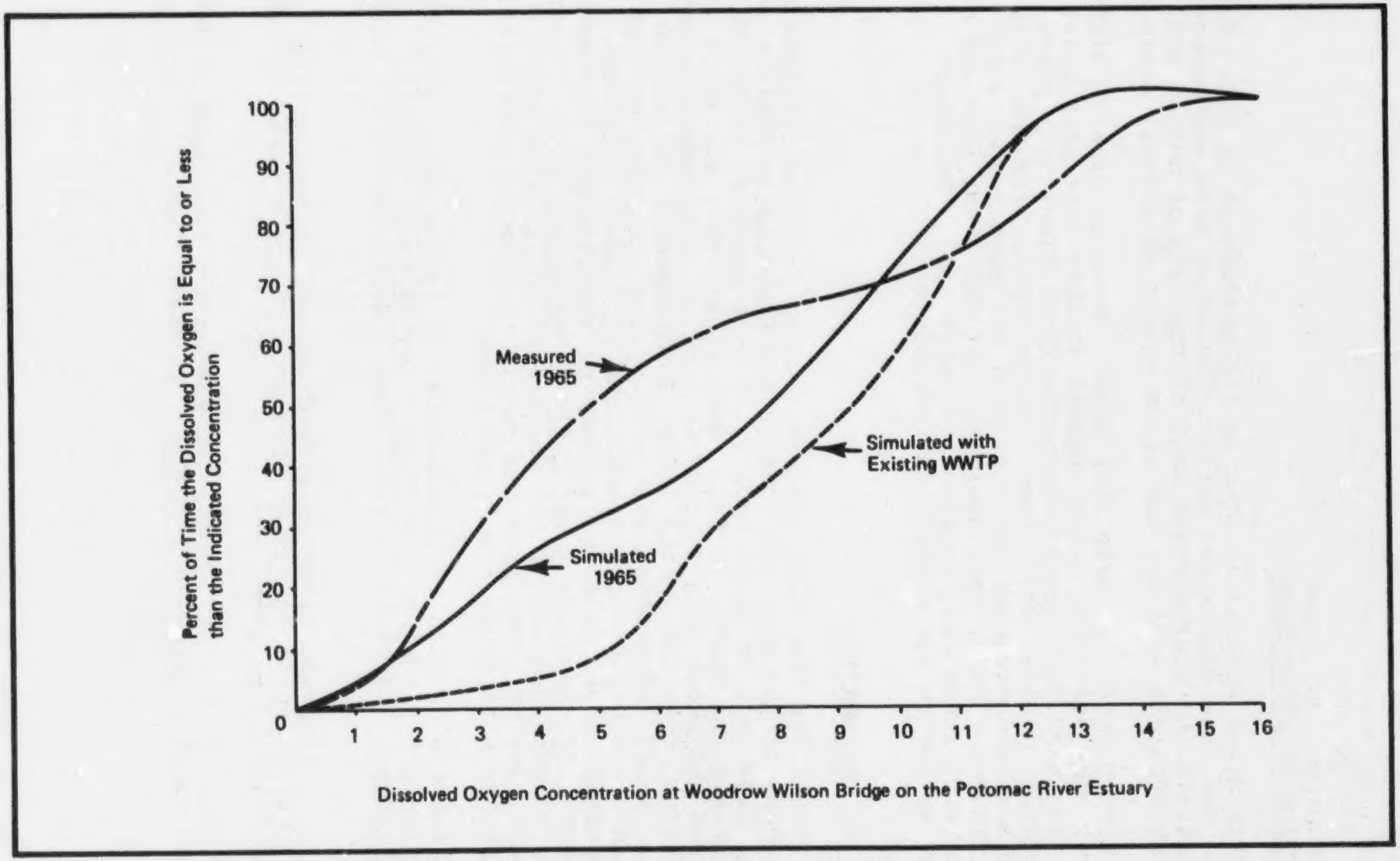


FIGURE A-2. Calibration of receiving water model at Washington, D.C.

DURHAM, NORTH CAROLINA

DESCRIPTION OF STUDY SITE

The Durham urban area is located at the headwaters of Third Fork Creek in the Cape Fear River Basin. The study area encompasses approximately the southwestern half of the City of Durham and is served by separate sanitary and storm sewers or natural drainage.

The receiving water is Third Fork Creek, which originates within the site. The receiving water segment reaches from just below the Durham Third Fork Creek Sewage Treatment Plant to a point approximately 4 miles downstream. Waste inputs from the urban area include urban runoff and municipal wastewater treatment plant effluent. Major characteristics of the study area and of the receiving water are presented in Table A-12. Pollutant loadings by source are summarized in Table A-13.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Flow data on Third Fork Creek were provided by the United States Geological Survey (USGS). Additional water quality data for the stream and those data related to wastewater treatment plants were obtained from the United States Environmental Protection Agency's STORET information retrieval system, the City of Durham Water Resources Division, conversations with local treatment plant operators, and selected volumes of the Triangle J Council of Governments' *208 Areawide Water Quality Management Plan*. Those selected volumes and additional sources of information which were utilized to define urban area and receiving water characteristics of the Durham site study are listed below.

1. Triangle J Council of Governments. *Areawide Water Quality Management Planning, 208 Project Inventory of Existing Resources*. Research Triangle Park. North Carolina. March 1976.

2. _____. *Areawide Water Quality Management Planning, 208 Pollution Source Analysis*. Research Triangle Park. North Carolina. July 1976.

3. Colston, N. V., Jr. Characterization and Treatment of Urban Land Runoff. *EPA-670/2-74-096*. December 1974.

4. United States Soil Conservation Service. Hydrology--SCS National Engineering Handbook, Section 4. 1972.

5. U.S. EPA, Office of Research and Development. Areawide Assessment Procedures Manual, Vol. I. EPA-600/9-76-014. July 1976.

CALIBRATION

The rainfall and pollution washoff portions of the model were calibrated to known prototype conditions. Annual runoff volumes were estimated based on rainfall and percent impervious area, as described in Reference 5. The linear STORM model equation was assumed for the runoff coefficient determination. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by assuming a constant base flow of 0.5 ft^3/sec since the stream's headwaters lie completely within the urban area. The modeled dissolved oxygen distribution in the receiving water correlated well with observed data. However, continuous observed receiving water quality data are unavailable; therefore, the receiving water response module could not be calibrated.

RESULTS

Simulation results indicate that suspended solids concentrations entering Third Fork Creek from the study site are in violation of the selected water quality criteria. The suspended solids problems could be solved by removal of suspended solids from the rainfall-induced effluent streams (urban runoff). The suspended solids removal requirements are summarized in Table A-14.

These simulation results indicated that dissolved lead concentrations and dissolved oxygen concentrations in Third Fork Creek were in compliance with the selected criteria.

Table A-12
Major Characteristics
Durham Site Study (Third Fork Creek Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 4, 10, 11, 12	2, 3, 5, 6, 7, 8, 9
Total seasonal rainfall (inches)	15.0	27.5
Mean time between storms (hours)	98.56	79.85
Mean duration of storm (hours)	8.98	7.43
Mean rainfall depth per event (inches)	0.2019	0.2429

Watershed Characteristics	Stormwater Runoff Watershed
Drainage area (acres)	5,275
Time of concentration (hours)	1.25
Washoff coefficient	2.30
Imperviousness (%)	30
Average annual runoff (inches)	15.7
BOD accumulation rate (lb/acre/day)	0.4560
TKN accumulation rate (lb/acre/day)	0.0238
Suspended solids accumulation rate (lb/acre/day)	17.300
Lead accumulation rate (lb/acre/day)	0.0065

Table A-12--Continued

	Stormwater Runoff Watershed
Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	8.52
Effluent limits (mg/l)	
BOD	10.0
SS	28.0
TKN	5.0
Pb	0.01
Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	0.5
Mean K2 value (1/day base e)	1.29
Kl value for CSO (1/day base e)	--
Kl value for stormwater and upstream flow (1/day base e)	0.38
Kl value for WWTP effluent (1/day base e)	0.55
Maximum monthly temperature (°C)	26.0
Mean background BOD (mg/l)	0
Mean background SS (mg/l)	50
Background pH	6.8
Background hardness (mg/l)	50

Table A-13
Pollutant Loading Summary
Durham Site Study (Third Fork Creek Basin)

Source	Average Pollutant Loads (lb/yr) BOD	TKN	SS	Pb
Upstream flow	0	0	0	0
WWTP effluent	165,245	82,623	462,687	165
Combined sewer overflow	NA	NA	NA	NA
Urban stormwater runoff	328,769	17,159	32,251,331	12,119
Total	494,014	99,782	32,414,018	12,284

Table A-14
Pollutant Removal Requirements
Durham Site Study (Third Fork Creek Basin)

Pollutant	Percent Removal Requirements by Source: Urban Stormwater Runoff	Overall
Suspended solids (SS)	97	97
Ultimate oxygen demand (UOD)	0	0
Lead (Pb)	0	0

ATLANTA, GEORGIA

DESCRIPTION OF STUDY SITE

The Atlanta urban area is located along a ridge separating three distinct river systems including the Chattahoochee River, the Flint River, and the South River. The study area is that portion of the Atlanta urban area that is tributary to the Chattahoochee River and includes all of the urbanized Peachtree Creek watershed. Approximately 6% of the study area is served by combined sewers. The remainder is either drained naturally or is served by storm sewers.

The receiving water is the Chattahoochee River, beginning just southwest of the urban area and extending approximately 70 miles downstream. Waste inputs from the urban area include urban runoff, combined sewer overflow, and municipal wastewater treatment plant effluent. Major characteristics of the study area and of the receiving water are presented in Table A-15. Pollutant loadings by source are summarized in Table A-16.

SOURCES OF INFORMATION

Rainfall and temperature data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data on the Chattahoochee River were provided by the United States Geological Survey (USGS) records. Additional water quality data for the river and those data related to wastewater treatment plants were obtained from the Environmental Protection Division of the Georgia Department of Natural Resources and from the City of Atlanta Bureau of Pollution Control. Cross-sectional data for the receiving water were furnished by the Department of the Army, Mobile District Corps of Engineers. Additional data which were utilized to define urban area and receiving water characteristics of the Atlanta study site were obtained from the following reports.

1. Black, Crow and Eidsness, Inc., and Jordan, Jones, and Goulding, Inc. Nonpoint Pollution Evaluation, Atlanta Urban Area. May 1975.
2. Black, Crow and Eidsness, Inc. Storm and Combined Sewer Pollution Sources and Abatement, Atlanta, Georgia. Water Pollution Control Research Series 11024 ELB 01/71. January 1971.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records. However, continuous observed receiving water quality data are unavailable; therefore, the receiving water response module could not be calibrated.

RESULTS

Simulation results indicate that removal of all three indicator pollutants (suspended solids, ultimate oxygen demand, and lead) will be required to meet the selected water quality criteria. These removal requirements are summarized in Table A-17.

The long-term dissolved lead criteria for soft water states that the mean concentration should not exceed 0.01 mg/l. The simulation results indicate that, for present conditions, the mean dissolved lead is 0.048 mg/l and that removal of all lead from combined sewer overflow and urban stormwater runoff would reduce this value to 0.033 mg/l. Thus, the lead criteria cannot be met by control of lead from CSO and urban runoff alone.

Table A-15
Major Characteristics
Atlanta Site Study (Chattahoochee River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 3, 4, 5, 6, 7, 12	8, 9, 10, 11
Total seasonal rainfall (inches)	35.72	12.62
Mean time between storms (hours)	67.54	100.50
Mean duration of storm (hours)	6.94	5.91
Mean rainfall depth per event (inch)	0.2588	0.2451

Watershed Characteristics	Combined Sewer Watershed	Stormwater Runoff Watershed
Drainage area (acres)	9,060	140,800
Time of concentration (hours)	2.15	19.20
Washoff coefficient	4.60	1.80
Imperviousness (%)	35	25
Average annual runoff (inches)	19.82	16.44
BOD accumulation rate (lb/acre/day)	3.2171	0.4925
TKN accumulation rate (lb/acre/day)	0.1848	0.0334
Suspended solids accumulation rate (lb/acre/day)	10.6000	3.9044
Lead accumulation rate (lb/acre/day)	0.0039	0.0028

Table A-15--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	185.22
Effluent limits (mg/l)	
BOD	30.0
SS	30.0
TKN	15.0
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	2,742
Mean K2 value (l/day base e)	0.95
Kl value for CSO (l/day base e)	0.44
Kl value for stormwater and upstream flow (l/day base e)	0.17
Kl value for WWTP effluent (l/day base e)	0.25
Maximum monthly temperature (°C)	19.70
Mean background BOD (mg/l)	1.83
Mean background SS (mg/l)	36.0
Background pH	6.7
Background hardness (mg/l)	10.0

Table A-16
Pollutant Loading Summary
Atlanta Site Study (Chattahoochee River Basin)

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	9.87	1.89	194.3	0.183
WWTP effluent	10.93	5.47	10.93	0.015
Combined sewer overflow	5.09	0.29	34.44	0.0126
Urban stormwater runoff	8.80	0.60	196.5	0.143
Total	34.69	8.25	436.17	0.3536

Table A-17
Pollutant Removal Requirements
Atlanta Site Study (Chattahoochee River Basin)

Pollutant	Percent Removal Requirements by Source Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	96	90	91
Ultimate oxygen demand (UOD)	--	--	92
Lead (Pb)	--	--	>100 (253)

DESCRIPTION OF STUDY SITE

The Ann Arbor urban area is bisected by the Huron River, which is tributary to Lake Erie. The study area is served entirely by separate storm and sanitary sewer systems.

The receiving reach of the Huron River begins just upstream from the Gedes Dam and continues for a distance of approximately 5-1/2 miles to the upstream limits of Ypsilanti Township. Waste inputs from the urban area include urban runoff and municipal and industrial wastewater treatment plant effluents. Major characteristics of the study area and of the receiving water are presented in Table A-18. Pollutant loadings by source are summarized in Table A-19.

SOURCES OF INFORMATION

Rainfall and temperature data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data on the Huron River were provided by the United States Geological Survey (USGS) records. Information on the wastewater treatment plants serving the urban area was obtained from the Environmental Protection Bureau of the Michigan Department of Natural Resources. Additional data which were utilized to define urban area and receiving water characteristics of the Ann Arbor study site were obtained from the following reports.

1. McElroy A. D., et al. Loading Functions for Assessment of Water Pollution from Nonpoint Sources. EPA-600/2-76-151. May 1976.
2. Southeast Michigan Council of Governments (SEMCOG). Urban Stormwater: Its Quality and Management. Detroit, Michigan. March 1978.
3. SEMCOG. Water Quality in Southeast Michigan: The Huron River Basin. Detroit, Michigan. February 1978.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records.

RESULTS

Simulation results indicate that removal of ultimate oxygen demand and suspended solids will be required to meet the selected water quality criteria. However, the wastewater treatment plant effluent was responsible for violations of the dissolved oxygen criteria, with no additional violations caused by urban runoff. That is, removal of the oxygen-demanding load from the urban stormwater runoff did not reduce the number of occurrences of DO levels below 2.0 mg/l. The removal requirements are summarized in Table A-20.

Table A-18
Major Characteristics
Ann Arbor Site Study (Huron River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 9, 10, 11	3, 4, 5, 6, 7, 8, 12
Total seasonal rainfall (inches)	12.28	21.16
Mean time between storms (hours)	95.19	90.50
Mean duration of storm (hours)	8.29	6.62
Mean rainfall depth per event (inches)	0.1351	0.1992

Watershed Characteristics	Stormwater Runoff Watershed
Drainage area (acres)	9,783
Time of concentration (hours)	2.83
Washoff coefficient	4.38
Imperviousness (%)	24
Average annual runoff (inches)	23.2
BOD accumulation rate (lb/acre/day)	0.2333
TKN accumulation rate (lb/acre/day)	0.0291
Suspended solids accumulation rate (lb/acre/day)	3.8360
Lead accumulation rate (lb/acre/day)	0.0047

Table A-18--Continued

Point Source Characteristics	Stormwater Runoff Watershed
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	20.35
Effluent limits (mg/l)	
BOD	30
SS	30
TKN	28
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	454
Mean K2 value (1/day base e)	0.20
Kl value for CSO (1/day base e)	N.A.
Kl value for stormwater and upstream flow (1/day base e)	0.16
Kl value for WWTP effluent (1/day base e)	0.23
Maximum monthly temperature (°C)	25.83
Mean background BOD (mg/l)	2.45
Mean background SS (mg/l)	5.5
Background pH	8.17
Background hardness (mg/l)	267.45

Table A-19
Pollutant Loading Summary
Ann Arbor Site Study (Huron River Basin)

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	2.57	0.71	5.46	0.003
WWTP effluent	1.20	1.11	1.20	0.000006
Combined sewer overflow	NA	NA	NA	NA
Urban stormwater runoff	0.82	0.10	13.51	0.017
Total	4.59	1.92	20.17	0.200

Table A-20
Pollutant Removal Requirements
Ann Arbor Site Study (Huron River Basin)

Pollutant	Percent Removal Requirements by Source: Urban Stormwater Runoff	Overall
Suspended solids (SS)	90	90
Ultimate oxygen demand (UOD)	0	0
Lead (Pb)	0	0

BUCYRUS, OHIO

DESCRIPTION OF STUDY SITE

Bucyrus, a small community located in central Ohio, is characterized by a predominantly flat landscape. The Sandusky River flows through the urban area and is tributary to Lake Erie. The entire urban area is served by a combined sewer system.

The Sandusky River is the receiving water, beginning west of the urban area and extending some 17 miles to its confluence with Broken Sword Creek. Waste inputs from the urban area include urban runoff and municipal wastewater treatment plant effluent. Major characteristics of the study area and of the receiving water are presented in Table A-21. Pollutant loadings by source are summarized in Table A-22.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data on the Sandusky River were provided by the United States Geological Survey (USGS) records. Additional data which were utilized to define urban area and receiving water characteristics of the Bucyrus study site were obtained from the following reports.

1. Burgess and Niple, Limited. Stream Pollution and Abatement from Combined Sewer Overflows. Columbus, Ohio. 1969.

2. Floyd G. Brown and Associates, Limited. Infiltration/Inflow Analysis Report, City of Bucyrus, Ohio. Marion, Ohio. 1974.

3. Burgess and Niple, Limited. Final Report, Land Use, Transportation, Parks and Open Space. Columbus, Ohio. 1974.

4. Floyd G. Brown and Associates, Limited. Facilities Plan for Wastewater Treatment Plant Improvement and Appurtenances, City of Bucyrus, Ohio. Marion, Ohio. 1976.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records. The modeled dissolved oxygen distribution in the receiving water correlated well with observed data. However, continuous observed receiving water quality data are unavailable. Therefore, the receiving water response module could not be calibrated.

RESULTS

Simulation results indicate that receiving water concentrations of dissolved oxygen and suspended solids are in violation of the selected water quality criteria. The simulation also indicates that the water quality criteria for ultimate oxygen demand and suspended solids can be met by removal of these constituents from the rainfall-induced wastewater streams (CSO and urban runoff). These removal requirements are summarized in Table A-23. The simulation results also indicated that dissolved lead concentrations in the Sandusky River were in compliance with the selected criteria.

Table A-21
Major Characteristics
Bucyrus Site Study (Sandusky River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 10, 12	3, 4, 5, 6, 7, 8, 9, 11
Total seasonal rainfall (inches)	9.9	25.8
Mean time between storms (hours)	57.17	60.94
Mean duration of storm (hours)	8.02	6.76
Mean rainfall depth per event (inches)	0.0770	0.1635

Watershed Characteristics	Combined Sewer Watershed
Drainage area (acres)	2,599
Time of concentration (hours)	0.52
Washoff coefficient	4.60
Imperviousness (%)	31.0
Average annual runoff (inches)	13.5
BOD accumulation rate (lb/acre/day)	0.5244
TKN accumulation rate (lb/acre/day)	0.0729
Suspended solids accumulation rate (lb/acre/day)	4.0200
Lead accumulation rate (lb/acre/day)	0.0016

Table A-21--Continued

Point Source Characteristics	Combined Sewer Watershed
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	6.51
Effluent limits (mg/l)	
BOD	6.00
SS	6.00
TKN	10.00
Pb	0.04
Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	80
Mean K2 value (1/day base e)	1.73
Kl value for CSO (1/day base e)	1.21
Kl value for stormwater and upstream flow (1/day base e)	0.49
Kl value for WWTP effluent (1/day base e)	0.70
Maximum monthly temperature (°C)	22.5
Mean background BOD (mg/l)	4.4
Mean background SS (mg/l)	202
Background pH	7.9
Background hardness (mg/l)	300

Table A-22
Pollutant Loading Summary
Bucyrus Site Study (Sandusky River Basin)

Source	Average Pollutant Loads (lb/yr) BOD	TKN	SS	Pb
Upstream flow	725,658	171,638	33,304,920	1,316
WWTP effluent	11,622	11,622	19,370	75
Combined sewer overflow	233,705	32,489	3,692,158	1,470
Urban stormwater runoff	NA	NA	NA	NA
Total	970,985	215,749	37,016,448	2,861

Table A-23
Pollutant Removal Requirements
Bucyrus Site Study (Sandusky River Basin)

	Percent Removal Requirements by Source	
Pollutant	Combined Sewer Overflow	Overall
Suspended solids (SS)	55	55
Ultimate oxygen demand (UOD)	83	83
Lead (Pb)	0	0

MILWAUKEE, WISCONSIN

DESCRIPTION OF STUDY SITE

The Milwaukee study area consists of all of the urban area tributary to the Milwaukee River south of the Milwaukee-Ozaukee County line in southeastern Wisconsin. Urban areas tributary to the Menomonee and Kinnickinnic Rivers are not included in this analysis. Approximately 17% of the study area is served by combined sewers. The combined sewer systems are located in the densely developed downtown area and, consequently, serve approximately 61% of the resident population. Approximately 62 discrete combined sewer overflow points discharge to the lower Milwaukee River. The remaining urban area upstream of the combined sewer systems is served by separate sewer systems and, thus, discharge stormwater runoff only to the Milwaukee River.

The receiving water is the lower reach of the Milwaukee River extending to the south into Milwaukee Bay. Waste sources include stormwater runoff and combined sewer overflow. Wastewater effluent from the Jones Island Wastewater Treatment Plant was not included in the analysis since discharge is directly into Lake Michigan. Also, as previously stated, flows from the Menomonee and Kinnickinnic Rivers were not included in the analysis, even though these rivers do discharge to Milwaukee Bay. Major characteristics of the study area and of the receiving water are presented in Table A-24. Pollutant loadings by source are summarized in Table A-25.

SOURCES OF INFORMATION

Rainfall and temperature data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow data on the Milwaukee River were provided by the United States Geological Survey (USGS) records. Background water quality data on this river were obtained from Envirex, Inc. Additional data which were utilized to define urban area and receiving water characteristics of the Milwaukee study site were obtained from the following reports.

1. Southeastern Wisconsin Regional Planning Commission. *A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin*. February 1974.

2. Meinholz, T. L. Analysis of Receiving Stream Impacts on the Milwaukee River. Presented at seminar on Combined Sewer Overflow Assessment and Control Procedures. Windsor Locks, Connecticut. 18 May 1978.

3. Stanley Consultants, Inc. *State of the Art of Water Pollution Control in Southeastern Wisconsin, Vol. 1, Point Sources*. July 1977.

4. Stanley Consultants, Inc. *State of the Art of Water Pollution Control in Southeastern Wisconsin, Vol. 3, Urban Stormwater Runoff*. July 1977.

5. Southeastern Wisconsin Regional Planning Commission. *Water Quality and Flow of Streams in Southeastern Wisconsin*. November 1966.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The upstream flow module was represented by actual observed streamflow records. However, long-term continuous observed receiving water quality data are unavailable; therefore, the receiving water response module could not be calibrated.

RESULTS

Simulation results indicate that the removal of ultimate oxygen demand (BOD and TKN) as well as suspended solids will be required to meet the selected water quality criteria. However, no lead removal is required. These removal requirements are summarized in Table A-26.

Results also show that the removal of all oxygen-demanding pollutants from combined sewer overflow and urban stormwater runoff would still leave the receiving water with DO criteria violations. Thus, the DO criteria cannot be met by control of pollutants from CSO and urban runoff alone.

Table A-24
Major Characteristics
Milwaukee Site Study (Milwaukee River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 3, 10, 11, 12	4, 5, 6, 7, 8, 9
Total seasonal rainfall (inches)	11.97	18.32
Mean time between storms (hours)	69.28	68.75
Mean duration of storm (hours)	9.68	6.94
Mean rainfall depth per event (inch)	0.0973	0.1692

Watershed Characteristics	Combined Sewer Watershed	Stormwater Runoff Watershed
Drainage areas (acres)	5,800	27,400
Time of concentration (hours)	5.30	13.50
Washoff coefficient	4.60	1.80
Imperviousness (%)	53	20
Average annual runoff (inches)	14.48	7.88
BOD accumulation rate (lb/acre/day)	1.7164	0.2256
TKN accumulation rate (lb/acre/day)	0.1299	0.0237
Suspended solids accumulation rate (lb/acre/day)	2.3659	0.9971
Lead accumulation rate (lb/acre/day)	0.0239	0.0017

Table A-24--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant	0
Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	381
Mean K2 value (1/day, base e)	0.45
K1 value for CSO (1/day, base e)	0.45
K1 value for stormwater and upstream flow (1/day, base e)	0.18
Maximum monthly temperature (°C)	26.0
Mean background BOD (mg/l)	3.40
Mean background SS (mg/l)	44.3
Background pH	7.8
Background hardness (mg/l)	337.0

Table A-25
Pollutant Loading Summary
Milwaukee Site Study (Milwaukee River Basin)

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	1.90	0.62	20.01	0.0074
WWTP effluent	0	0	0	0
Combined sewer overflow	1.85	0.14	4.94	0.0500
Urban stormwater runoff	0.60	0.06	9.84	0.0163
Total	4.35	0.82	34.79	0.0737

Table A-26
Pollutant Removal Requirements
Milwaukee Site Study (Milwaukee River Basin)

Pollutant	Percent Removal Requirements by Source: Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	85	80	82
Ultimate oxygen demand (UOD)	--	--	93[a]
Lead (Pb)	0	0	0

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[a] This overall UOD removal will result in elimination of 90% of the DO occurrences less than 2.0 mg/l which can be eliminated by control of CSO and urban stormwater runoff.

DES MOINES, IOWA

DESCRIPTION OF STUDY SITE

The Des Moines urban area is located in central Iowa at the confluence of the Des Moines and Raccoon Rivers. The study area consisted of the Des Moines urban area tributary to the Des Moines and Raccoon Rivers, lying upstream of the wastewater treatment plant. The extent of the combined sewer watershed is about 8% by area. The remainder is served by storm sewers or by natural drainage.

The receiving water consists of the Des Moines River below the confluence with the Raccoon River near the wastewater treatment plant, extending to the Red Rock impoundment at State Highway 14, a total of approximately 45 miles of stream length. Major characteristics of the study area and of the receiving water are presented in Table A-27.

Waste sources input to the Des Moines River included municipal and industrial wastewaters as well as combined sewer overflow and stormwater runoff. Pollutant loadings by source are summarized in Table A-28.

SOURCES OF INFORMATION

Climatological data for the Des Moines area were taken from the records of the National Oceanic and Atmospheric Administration (NOAA). Flow records for the Raccoon and Des Moines Rivers were provided by the United States Geological Survey (USGS). Background water quality data were provided by the USGS and the State Hygienic Laboratory (University of Iowa).

Additional data concerning the demographic characteristics, waste source strengths, and watershed hydrology were obtained from the following sources.

1. Henningson, Durham & Richardson, Inc. Combined Sewer Overflow Abatement Plan, Des Moines, Iowa. EPA-R2-73-170. April 1974.
2. Iowa Water Quality Management Plan, Des Moines River Basin. (Draft) Iowa Department of Environmental Quality. July 1975.
3. Iowa Water Quality Report. Iowa Department of Environmental Quality. April 1975.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records. However, continuous observed receiving water quality data are unavailable; therefore, the receiving water response module could not be calibrated.

RESULTS

The results of the 10-year simulations summarized in Table A-29 indicate that fish and wildlife dissolved oxygen criteria will not be met for even total removal of the combined sewer overflow and stormwater loads. That is, the fish and wildlife criteria for dissolved oxygen cannot be met by control of combined sewer overflow and stormwater runoff alone.

Based on the results of the simulation, the fish and wildlife criteria for suspended solids and lead will not be violated at the present conditions with no control of combined sewer overflow and stormwater runoff.

Table A-27
Major Characteristics
Des Moines Site Study (Des Moines River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 3, 11 12	4, 5, 6, 7, 8, 9, 10
Total seasonal rainfall (inches)	8.26	29.53
Mean time between storms (hours)	97.18	71.17
Mean duration of storm (hours)	9.92	6.79
Mean rainfall depth per event (inch)	0.0865	0.1912

Watershed Characteristics	Combined Sewer Watershed	Stormwater Runoff Watershed
Drainage area (acres)	4,018	45,000
Time of concentration (hours)	3.20	9.10
Washoff coefficient	4.6	2.1
Imperviousness (%)	37.7	33.1
Average annual runoff (inches)	12.51	10.98
BOD accumulation rate (lb/acre/day)	1.276	1.050
TKN accumulation rate (lb/acre/day)	0.1680	0.0700
Suspended solids accumulation rate (lb/acre/day)	2.1200	2.5000
Lead accumulation rate (lb/acre/day)	0.0120	0.0077

Table A-27--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	62.50
Effluent limits (mg/l)	
BOD	30.20
SS	30.20
TKN	11.00
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	4,280.0
Mean K2 value (l/day base e)	0.77
Kl value for CSO (l/day base e)	0.46
Kl value for stormwater and upstream flow (l/day base e)	0.18
Kl value for WWTP effluent (l/day base e)	0.26
Maximum monthly temperature (°C)	25.0
Mean background BOD (mg/l)	6.08
Mean background SS (mg/l)	233.0
Background pH	8.3
Background hardness (mg/l)	341.0

Table A-28
Pollutant Loading Summary
Des Moines Site Study (Des Moines River Basin)

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	38.99	11.99	3,504.24	0.03
WWTP effluent	3.71	1.35	3.71	0.005
Combined sewer overflow	0.70	0.09	3.03	0.02
Urban stormwater runoff	4.72	0.32	39.65	0.12
Total	48.12	13.75	3,550.63	0.175

Table A-29
Pollutant Removal Requirements
Des Moines Site Study (Des Moines River Basin)

	Percent Removal Requirements by Source		
Pollutant	Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	0	0	0
Ultimate oxygen demand (UOD)	--	--	90[a]
Lead (Pb)	0	0	0

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[a] This overall UOD removal will result in elimination of 90% of the DO occurrences less than 2.0 mg/l which can be eliminated by control of CSO and urban stormwater runoff.

SPRINGFIELD, MISSOURI

DESCRIPTION OF STUDY SITE

The Springfield study area is located in the Missouri Ozark Plateau Province of the White River basin. It is an area of karst terrain with numerous sinkholes providing direct flow between surface and ground waters. The urban area is served entirely by separate storm and sanitary sewers. Urban runoff was simulated from two characteristically unique urban drainage basins of Wilson's Creek. Urban watershed No. 1 encompasses the central Springfield business district, with a developed population density of approximately six persons per acre. Urban watershed No. 2 is located southwest of Springfield with an average population density of two persons per acre and receives effluent from the recently constructed 30-mgd advanced wastewater treatment plant (AWT). Summer thunderstorms have resulted in severe fish kills in the James River due to low dissolved oxygen concentrations in Wilson's Creek.

Conceptually, the James River receiving water model combines urban runoff from watersheds No. 1 and No. 2, AWT effluent, and upstream flow at the confluence of the James River and Wilson's Creek during a 4-hour time step and simulates DO, SS, and Pb concentrations for 70 miles of river. Model input data for rainfall, watershed characteristics, AWT effluent, and James River receiving water characteristics are presented in Table A-30.

Annual pollutant loads for BOD_5, TKN, SS, and Pb from the four sources are shown in Table A-31. Upstream James River flow is the source for approximately 50%, 45%, and 79% of the total loads for BOD_5, TKN, and SS, respectively. Runoff from urban watershed No. 1 is the source for approximately 85% of the total load for Pb.

SOURCES OF INFORMATION

Rainfall and temperature data for Springfield were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data for the James River and Wilson's Creek were provided by USGS records from five sampling stations, three of which provide continuous dissolved oxygen data. Additional water quality data for surface waters and wastewater treatment plant effluent were provided by the City of Springfield. Drainage basin boundaries were determined from 1:24,000-scale, 7-1/2-minute USGS quadrangle maps. Additional data for the Springfield study site were obtained from the following sources.

1. James River-Wilson Creek Study, Springfield, Missouri. Volumes I and II. Robert S. Kerr Water Research Center, Ada, Oklahoma. June 1969.

2. Hayes, W. C. Urban Development in a Karst Terrain. City of Springfield, Missouri. October 1977.

3. Personal Communication. Dr. William C. Hayes, Environmental Geologist. City of Springfield, Missouri.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known or estimated prototype conditions. The dry-weather flow portion of the simulation is based on actual wastewater treatment plant records for 1974 from the Southwest Springfield Wastewater Treatment Plant. At that time, the Southwest wastewater treatment plant was a secondary plant which has recently been upgraded to AWT. The upstream flow module was represented by actual observed streamflow records from the James River above Wilson's Creek. Dissolved oxgyen concentrations from the receiving water simulation were calibrated to 4 years (October 1973 to September 1977) of continuous USGS DO measurements at Frazier Bridge on the James River. This calibration represents conditions existing at the time of the DO measurements, i.e., secondary wastewater treatment.

To simulate observed dissolved oxygen concentrations in the James River prior to the operation of the new AWT facility, 80% of the 1974 wastewater treatment plant effluent pollutants were assumed to deposit uniformly in Wilson's Creek where they were flushed to the receiving water (James River) during periods of runoff. Figure A-3 indicates that the simulated cumulative dissolved oxygen frequency curve agrees well with the observed frequency curve. Also shown on Figure A-3 is the simulated cumulative dissolved oxygen frequency curve with the existing AWT effluent quality parameters. It appears that substantial water quality benefits can be expected in the James River due to construction of this AWT facility.

RESULTS

Continuous simulation of existing James River water quality conditions indicates that 30% removal of ultimate oxygen demand (BOD and TKN) from urban runoff is required to reduce the current estimated average of 10 DO violations per year to one violation per year. An overall 41% removal of SS is required to prevent the mean concentration of urban runoff SS from exceeding the mean background SS concentration in the James River. Dissolved lead criteria are met under existing conditions. These removal requirements are summarized in Table A-32.

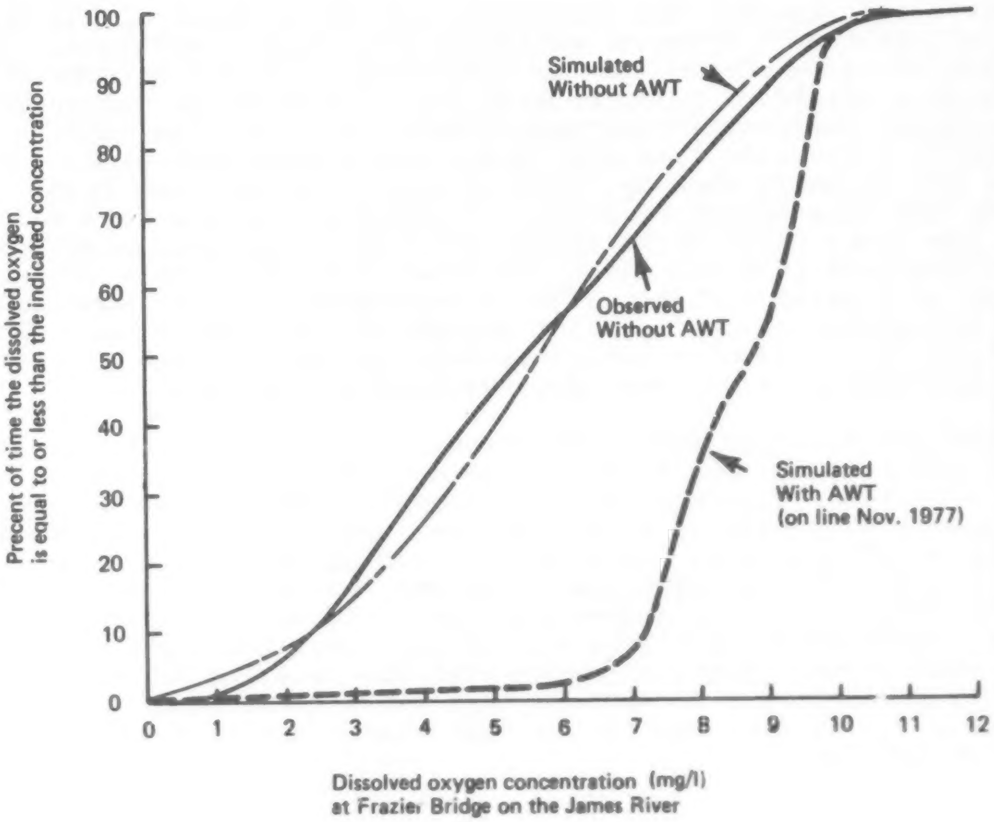

FIGURE A-3. Calbration of receiving water model at Springfield, Missouri.

Table A-30
Major Characteristics Springfield Site Study

Rainfall Characteristics	Season 1	Season 2
Months in each season	1, 2, 3, 11, 12	4, 5, 6, 7, 8, 9, 10
Total rainfall (inches)	13.18	26.22
Mean time between storms (hours)	85.73	81.24
Mean duration of storm (hours)	8.83	6.61
Mean rainfall depth per event (inch)	0.3860	0.4601

Watershed Characteristics	Urban Watershed No. 1	Urban/Rural Watershed No. 2
Drainage area (acres)	18,782	15,128
Time of concentration (hours)	7.25	4.71
Washoff coefficient	3.50	4.60
Imperviousness (%)	25	15
Average annual runoff (inches)	13.32	13.32
BOD accumulation rate (lb/acre-day)	0.1230	0.168
TKN accumulation rate (lb/acre-day)	0.0139	0.0400
SS accumulation rate (lb/acre-day)	0.7370	0.4660
Pb accumulation rate (lb/acre-day)	0.0059	0.0008

Table A-30--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant (ft^3/sec)	37.64
Existing effluent limits (mg/l)	
BOD	10.0
SS	10.0
TKN	3.0
Pb	0.02

Receiving Water (James River) Characteristics	
Mean annual upstream flow (ft^3/sec)	215.0
Specified mean K2 (1/day base e)	1.14
K1 for stormwater and upstream flow	1.00
K1 for WWTP effluent	1.42
Maximum monthly temperature (°C)	30.50
Mean background BOD (mg/l)	1.89
Mean background SS (mg/l)	48.33
Background pH	8.00
Background hardness (mg/l)	153.0

Table A-31
Pollutant Loading Summary
Springfield Site Study

Source	Average Pollutant Loads (lb/yr) BOD$_5$	TKN	SS	Pb
Upstream flow	1,148,383	217,669	30,133,750	2,526
AWT effluent	741,000	222,000	741,000	1,500
Watershed No. 1 runoff	297,500	33,420	5,184,000	41,460
Watershed No. 2 runoff	112,400	13,860	1,974,000	3,044
Total	2,229,283	486,949	38,032,750	48,530

Table A-32
Pollutant Removal Requirements
Springfield Site Study

Parameter	Percent Removal Requirements by Source Urban Runoff Basin 1	Urban Runoff Basin 2	Overall
SS	49.0	19.0	40.7
UOD	30.0	30.0	30.0
Pb	0.0	0.0	0.0

DESCRIPTION OF STUDY SITE

The Tulsa urban area is located on a ridge defining two distinct drainage patterns. A portion of the City drains to the Arkansas River, while the study area is that portion to the north and east of the ridge for which Bird Creek is the receiving stream. This area is served entirely by separate storm and sanitary sewer systems.

The receiving zone of Bird Creek begins north of the Tulsa International Airport and extends some 6 miles downstream to its confluence with the Verdigris River and eventually the Arkansas River. Waste inputs from the urban area include urban runoff, municipal wastewater treatment plant effluents, and industrial wastewater treatment plant effluents. Major characteristics of the study area and of the receiving water are presented in Table A-33. Pollutant loadings by source are summarized in Table A-34.

SOURCES OF INFORMATION

Rainfall and temperature data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality data on Bird Creek were provided by the United States Geological Survey (USGS) records. Additional data which were utilized to define urban area and receiving water characteristics of the Tulsa study site were obtained from the following reports.

1. McElroy, A. D., et al. Loading Functions for Assessment of Water Pollution from Nonpoint Sources. EPA-600/2-76-151. May 1976.
2. Avco Economic Systems Corporation. Stormwater Pollution from Urban Land Activity, Tulsa, Oklahoma. Federal Water Quality Administration, U.S. Department of the Interior, Washington, D.C. 1970.
3. Indian Nations Council of Governments (INCOG). Working Paper No. T-1, Water Quality Problem Areas, Tulsa, Oklahoma. 1977.
4. INCOG. Working Paper No. T-7, Wastewater Treatment Community Profiles, Tulsa, Oklahoma. 1977.

5. INCOG. Working Paper No. T-8, Future Wastewater Flows, Volume II, Part A, Tulsa, Oklahoma. 1977.

6. INCOG. Working Paper No. T-8, Future Wastewater Flows, Vol. II, Part B, Tulsa, Oklahoma. 1978.

7. INCOG. Assessment of Nonpoint Source Pollution for the INCOG 208 Study Area, Tulsa, Oklahoma. 1978.

8. INCOG. Nonpoint Source Control Plan for the INCOG 208 Study Area, Tulsa, Oklahoma. 1978.

9. INCOG. Nonpoint Source Control Plan for the INCOG 208 Study Area, Appendix, Tulsa, Oklahoma. 1978.

10. INCOG. Regional BOD and Nutrient Generation, Tulsa, Oklahoma. 1978.

11. INCOG. Significant Industrial Point Source Inventory for the INCOG Study Output 3B, Tulsa, Oklahoma. 1978.

CALIBRATION

The rainfall, runoff, and pollution washoff portions of the model were calibrated to known prototype conditions. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records. The receiving water quality response module agreed well with observed records. However, the data base was insufficient to achieve a complete calibration.

RESULTS

Simulation results indicate that removal of suspended solids and lead is necessary to meet the selected water quality criteria. There are no dissolved oxygen problems indicated. The removal requirements are summarized in Table A-35.

Table A-33
Major Characteristics
Tulsa Site Study (Bird Creek Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	1, 2, 3, 11, 12	4, 5, 6, 7, 8, 9, 10
Total seasonal rainfall (inches)	27.62	10.38
Mean time between storms (hours)	119.46	94.45
Mean duration of storm (hours)	8.47	6.20
Mean rainfall depth per event (inch)	0.1491	0.3340

Watershed Characteristics	Stormwater Runoff Watershed
Drainage area (acres)	78,084
Time of concentration (hours)	3.14
Washoff coefficient	2.20
Imperviousness (%)	30.0
Average annual runoff (inches)	13.61
BOD accumulation rate (lb/acre/day)	0.2614
TKN accumulation rate (lb/acre/day)	0.0186
Suspended solids accumulation rate (lb/acre/day)	5.6254
Lead accumulation rate (lb/acre/day)	0.0140

Table A-33--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	32.485
Effluent limits (mg/l)	
BOD	30
SS	30
TKN	35
Pb	0.05
Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	500
Mean K2 value (1/day base e)	0.978
Kl value for CSO (1/day base e)	N.A.
Kl value for stormwater and upstream flow (1/day base e)	0.24
Kl value for WWTP effluent (1/day base e)	0.35
Maximum monthly temperature (¼C)	29.17
Mean background BOD (mg/l)	7.0
Mean background SS (mg/l)	127.0
Background pH	7.86
Background hardness (mg/l)	218.68

Table A-34
Pollutant Loading Summary
Tulsa Site Study (Bird Creek Basin)

Source	Average Pollutant Loads (lb/yr) BOD	TKN	SS	Pb
Upstream flow	6,387,391	1,424,783	115,886,398	82,117
WWTP effluent	1,382,722	306,845	1,620,527	3,196
Combined sewer overflow	0	0	0	0
Urban stormwater runoff	2,572,809	183,072	155,884,748	387,949
Total	10,342,922	1,914,700	273,391,623	473,262

Table A-35
Pollutant Removal Requirements
Tulsa Site Study (Bird Creek Basin)

Pollutant	Percent Removal Requirements by Source Urban Stormwater Runoff	Overall
Suspended solids (SS)	80	80
Ultimate oxygen demand (UOD)	0	0
Lead (Pb)	40	40

SACRAMENTO, CALIFORNIA

DESCRIPTION OF STUDY SITE

The Sacramento urban area consists of the City of Sacramento as well as numerous developed areas nearby. The study area includes the urban area that is tributary to the Sacramento River between miles 53 and 63, including the American River below Folsom Lake. The downtown section of the City of Sacramento is served by combined sewers and comprises approximately 7% of the study area. The remainder is either drained naturally or is served by storm sewers.

The receiving water is the Sacramento River beginning just south of the urban area and extending approximately 50 miles downstream. Waste inputs from the urban area include urban runoff, combined sewer overflow, and municipal, industrial, and food processing wastewater treatment plant effluents. Major characteristics of the study area and of the receiving water are presented in Table A-36. Pollutant loadings by source are summarized in Table A-37.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and part of the background water quality data on the Sacramento River were provided by the United States Geological Survey (USGS) records. Additional data which were utilized to define urban area and receiving water characteristics of the Sacramento study site were obtained from the following reports.

1. U.S. Environmental Protection Agency. Environmental Impact Statement, Sacramento Regional Wastewater Management Program. April 1975.

2. Sacramento Area Consultants. Stormwater Control System, Sacramento Regional Wastewater Management Program. August 1975.

3. J. B. Gilbert and Associates. Feasibility Study, Elimination of Wastewater Bypassing, City of Sacramento. September 1973.

4. U.S. Environmental Protection Agency. Urban Storm Runoff and Combined Sewer Overflow Pollution, Sacramento, California. December 1971.

5. McElroy, A. D., et al. Loading Functions for Assessment of Water Pollution from Nonpoint Sources. EPA-600/2-76-151. May 1976.

CALIBRATION

The rainfall portion of the model was calibrated to known prototype conditions. The runoff in the combined watershed was made to match the overflow recorded at sumps No. 1 and No. 2 and the runoff from the separate area was adjusted to runoff values cited in Reference 2. The pollution washoff was calibrated to known prototype conditions. The volume of dry-weather flow was based on historic wastewater treatment plant flow records. Effluent quality was based on secondary requirements of 30 mg/l BOD, 30 mg/l SS, 28 mg/l TKN, and 0.04 mg/l Pb. The modeled dissolved oxygen distribution in the receiving water correlated well with observed data. However, continuous observed receiving water quality data are unavailable; therefore, precise calibration of the receiving water module could not be accomplished.

RESULTS

Simulation results indicate that removal of suspended solids and lead will be required to meet the selected water quality criteria. Dissolved oxygen criteria are met under present conditions. Removal requirements are summarized in Table A-38.

It is noted that the complete removal of lead from urban runoff and combined sewer overflow will not be sufficient to meet the lead criteria.

Table A-36
Major Characteristics
Sacramento Study Site (Sacramento River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	4, 5, 6, 7, 8, 9, 10	1, 2, 3, 11, 12
Total seasonal rainfall (inches)	3.28	13.74
Mean time between storms (hours)	354	84
Mean duration of storm (hours)	6.7	10.5
Mean rainfall depth per event (inch)	0.14	0.1376

Watershed Characteristics	Combined Sewer Watershed	Stormwater Runoff Watershed
Drainage area (acres)	7,000	93,000
Time of concentration (hours)	1.0	11.6
Washoff coefficient	4.6	1.7
Imperviousness (%)	70	50
Average annual runoff (inches)	5.5	6.75
BOD accumulation rate (lb/acre/day)	3.462	0.329
TKN accumulation rate (lb/acre/day)	0.3055	0.0310
Suspended solids accumulation rate (lb/acre/day)	1.820	0.5300
Lead accumulation rate (lb/acre/day)	0.0014	0.0010

Table A-36--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	150
Effluent limits (mg/l)	
BOD	30
SS	30
TKN	28
Pb	0.04

Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	24,670
Mean K2 value (1/day base e)	0.17
K1 value for CSO (1/day base e)	0.40
K1 value for stormwater and upstream flow (1/day base e)	0.16
K1 value for WWTP effluent (1/day base e)	0.23
Maximum monthly temperature (°C)	22.3
Mean background BOD (mg/l)	2.0
Mean background SS (mg/l)	58.9
Background pH	7.5
Background hardness (mg/l)	60

Table A-37
Pollutant Loading Summary
Sacramento Site Study (Sacramento River Basin)

Source	Average Pollutant Loads (10^6 lb/yr) BOD	TKN	SS	Pb
Upstream flow	71.5	7.7	2,320	0.715
WWTP effluent	13.5	12.6	13.5	0.018
Combined sewer overflow	1.65	0.147	4.56	0.0036
Urban stormwater runoff	2.01	0.189	17.60	0.0332
Total	88.66	20.6	2,356	0.7698

Table A-38
Pollutant Removal Requirements
Sacramento Site Study (Sacramento River Basin)

Pollutant	Percent Removal Requirements by Source Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	89	52	54
Ultimate oxygen demand (UOD)	--	--	0
Lead (Pb)	--	--	>100

DESCRIPTION OF STUDY SITE

The Castro Valley urban area is located just east of San Francisco Bay on the fringe of the urban area surrounding the bay. The study area is that portion of the urban area that is tributary to San Lorenzo Creek downstream of Crow Creek to downstream of Castro Valley Creek. The entire study area is either served by separate sewers or is drained naturally.

The receiving water is San Lorenzo Creek beginning just downstream of Castro Valley Creek and extending approximately 5.1 miles downstream to San Francisco Bay. The effects of downstream urbanization have not been included in this study. Waste inputs from the urban area include urban runoff only. Major characteristics of the study area and of the receiving water are presented in Table A-39. Pollutant loadings by source are summarized in Table A-40.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration (NOAA). Upstream flow and background water quality on San Lorenzo Creek were provided by the United States Geological Survey (USGS) records. Additional water quality data for San Lorenzo Creek and Castro Valley Creek were obtained from the United States Environmental Protection Agency.

CALIBRATION

The rainfall portion of the model was calibrated to known prototype conditions. The runoff was calibrated using information from the USGS gage on Castro Valley Creek. The results were then applied to the entire study area. The pollution washoff was similarly calibrated using information from the Castro Valley Creek gagesite. The upstream flow in San Lorenzo Creek was simulated using a base flow (3 ft^3/sec) and runoff related to rainfall on the urban area. The mean flow in San Lorenzo Creek was adjusted to match the mean flow from the USGS gage. Continuous receiving water quality data are unavailable; therefore, precise calibration of the receiving water response could not be accomplished.

RESULTS

Simulation results indicate that removal of all three indicator pollutants (suspended solids, ultimate oxygen demand, and lead) will be required to meet the selected water quality criteria. Those removal requirements are summarized in Table A-41.

Table A-39
Major Characteristics
Castro Valley Study Site (San Lorenzo Creek)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	5, 6, 7, 8, 9	1, 2, 3, 4, 10, 11, 12
Total seasonal rainfall (inches)	0.87	16.89
Mean time between storms (hours)	486.6	101.67
Mean duration of storm (hours)	5.55	11.06
Mean rainfall depth per event (inch)	0.0682	0.1552

Watershed Characteristics	Natural (Upstream) Watershed	Stormwater Runoff Watershed
Drainage area (acres)	24,490	3,850
Time of concentration (hours)	<4	<4
Washoff coefficient	2.5	5.0
Imperviousness (%)	0.0	>60
Average annual runoff (inches)	5.22	9.4
BOD accumulation rate (lb/acre/day)	0.08	0.662
TKN accumulation rate (lb/acre/day)	0.012	0.0662
Suspended solids accumulation rate (lb/acre/day)	1.0	3.46
Lead accumulation rate (lb/acre/day)	0.0	0.0029

Table A-39--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	0
Effluent limits (mg/l)	0
BOD	0
SS	0
TKN	0
Pb	
Receiving Water Characteristics	
Mean annual upstream flow (ft^2/sec)	14.7
Mean K2 value (l/day base e)	5.9
Kl value for CSO (l/day base e)	N.A.
Kl value for stormwater and upstream flow (l/day base e)	0.22
Kl value for WWTP effluent (l/day base e)	N.A.
Maximum monthly temperature (°C)	22.5
Mean background BOD (mg/l)	0.5
Mean background SS (mg/l)	20
Background pH	7.5
Background hardness (mg/l)	100

Table A-40
Pollutant Loading Summary
Castro Valley Study Site (San Lorenzo Creek)

Source	Average Pollutant Loads (lb/yr) BOD	TKN	SS	Pb
Upstream flow	114,000	23,000	8,880,000	66
WWTP effluent	0	0	0	0
Combined sewer overflow	0	0	0	0
Urban stormwater runoff	291,000	29,200	4,780,000	4,000
Total	405,000	52,000	13,660,000	4,066

Table A-41
Pollutant Removal Requirements
Castro Valley Study Site (San Lorenzo Creek)

Pollutant	Percent Removal Requirements by Source: Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	--	95.6	95.6
Ultimate oxygen demand (UOD)	--	13	13
Lead (Pb)	--	95	95

PORTLAND, OREGON

DESCRIPTION OF STUDY SITE

The Portland urban area is located between the Columbia River, to the north, and the Willamette River, to the south, just above their confluence. The study area included only those portions tributary to the Willamette and downstream from where the Clackamas River enters the Willamette. The study basin is served by a combined sewer system except in a few newly developed areas where separate systems have been constructed. The basin was assumed to behave as a totally combined sewered area.

The receiving water is the Willamette River beginning at Ross Island and extending 14 miles downstream to Kelly Point. The receiving water is tidally influenced over its entire length. Waste inputs from the urban area include combined sewer overflow and municipal wastewater treatment plant effluent. Major characteristics of the study area and of the receiving water are presented in Table A-42. Pollutant loadings by source are presented in Table A-43.

SOURCES OF INFORMATION

Rainfall data for the study site were taken from the climatological data records of the National Oceanic and Atmospheric Administration. Upstream flow and background water quality data on the Willamette River were provided by the United States Geological Survey (USGS) records and the United States Environmental Protection Agency's STORET information retrieval system. Additional water quality data for the river and those data related to wastewater treatment plants were obtained from various agencies of the City of Portland and also from selected volumes of the Columbia Region Association of Governments (CRAG) 208 Waste Treatment Management Study. Those selected volumes and additional sources of information which were utilized to define urban area and receiving water characteristics of the Portland site study are listed below.

1. CH2M HILL for Columbia Region Association of Governments, Proposed Plan, Areawide Waste Treatment Management Study, Volume 1. 15 November 1977.

2. CH2M HILL for CRAG, 208 Plan Technical Supplement No. 1, Planning Constraints. 15 November 1977.

3. City of Portland for CRAG, 208 Plan Technical Supplement No. 2. Water Quality Aspects of Combined Sewer Overflows. 15 November 1977.

4. U.S. EPA, Office of Research and Development. Areawide Assessment Procedures Manual, Volume I. EPA-600/9-76-014. July 1976.

5. Rickert, D. A., et al. Planning Implications of DO Depletion in the Willamette River, Oregon. EPA-600/9-76-016. 1976.

6. Hartigan, J. P., et al. Planning for Nonpoint Pollution Impacts. Presented at ASCE Urban Planning and Development Division Specialty Conference, Anaheim, California. 25-27 July 1977.

CALIBRATION

The rainfall and pollution washoff portions of the model were calibrated to known prototype conditions. Annual runoff volumes were estimated based on rainfall and percent impervious area, as described in Reference 4. The linear STORM model equation was assumed for the runoff coefficient determination. The dry-weather flow portion of the simulation is based on historic wastewater treatment plant flow data, and the upstream flow module was represented by actual observed streamflow records. The modeled dissolved oxygen distribution in the receiving water correlated well with available observed data. However, continuous observed receiving water quality data are unavailable; therefore, the receiving water response module could not be precisely calibrated.

RESULTS

Simulation results indicate that receiving water concentrations of dissolved oxygen, suspended solids, and long-term dissolved lead are in violation of the selected water quality criteria. The simulation also indicates that the water quality criteria for ultimate oxygen demand and suspended solids can be met by removal of these constituents from the rainfall-induced wastewater systems (CSO and urban runoff). These removal requirements are summarized in Table A-44.

The long-term dissolved lead criteria for soft water states that the mean concentration should not exceed 0.01 mg/l. Background levels of dissolved lead in the Willamette River are in exceedance of the criteria and, therefore, this problem cannot be solved by control of dissolved lead from CSO and urban runoff alone.

Table A-42
Major Characteristics
Portland Site Study (Willamette River Basin)

Rainfall Characteristics	Season No. 1	Season No. 2
Months in each season	6, 7, 8, 9	1, 2, 3, 4, 5, 10, 11, 12
Total seasonal rainfall (inches)	4.48	33.13
Mean time between storms (hours)	118.79	42.90
Mean duration of storm (hours)	8.07	12.67
Mean rainfall depth per event (inch)	0.2285	0.3630

Watershed Characteristics	Combined Sewer Watershed
Drainage area (acres)	51,394
Time of concentration (hours)	3.33
Washoff coefficient	4.60
Imperviousness (%)	35
Average annual runoff (inches)	15.4
BOD accumulation rate (lb/acre/day)	0.3288
TKN accumulation rate (lb/acre/day)	0.0283
Suspended solids accumulation rate (lb/acre/day)	0.3126
Lead accumulation rate (lb/acre/day)	0.0003

Table A-42--Continued

Point Source Characteristics	
Mean daily dry-weather flow from treatment plant(s) (ft^3/sec)	13.95
Effluent limits (mg/l)	
BOD	20.0
SS	20.0
TKN	5.0
Pb	0.01
Receiving Water Characteristics	
Mean annual upstream flow (ft^3/sec)	24,000
Mean K2 value (1/day base e)	0.08
K1 value for CSO (1/day base e)	0.40
K1 value for stormwater and upstream flow (1/day base e)	0.16
K1 value for WWTP effluent (1/day base e)	0.23
Maximum monthly temperature (°C)	22.0
Mean background BOD (mg/l)	1.0
Mean background SS (mg/l)	16
Background pH	6.9
Background hardness (mg/l)	24

Table A-43
Pollutant Loading Summary
Portland Site Study (Willamette River Basin)

Source	Average Pollutant Loads (lb/yr) BOD	TKN	SS	Pb
Upstream flow	6,517,371	4,201,346	137,328,845	114,024
WWTP effluent	540,432	135,108	540,432	270
Combined sewer overflow	2,703,736	232,712	5,483,645	5,550
Urban stormwater runoff	--	--	--	--
Total	9,761,539	4,369,096	143,652,952	119,844

Table A-44
Pollutant Removal Requirements
Portland Site Study (Willamette River Basin)

Pollutant	Percent Removal Requirements by Source: Combined Sewer Overflow	Urban Stormwater Runoff	Overall
Suspended solids (SS)	22	--	22
Ultimate oxygen demand (UOD)	18	--	18
Lead (Pb)	>100	--	>100

APPENDIX B

URBANIZED AREA DATA BASE

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                    URBANIZED AREA DATA BASE LISTING


SEQ NO  72 U.A NO.  40101 UA NAME BIRMINGHAM AL              CSO AREA       0. CSO POP          0.
UA POP    558099. UA SIZE  224.6 70 SMSA POP   767230.
2000 SMSA POP   915700. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 53.52
 RW CLASS  1 FLOW      0. % DRAINED  30.00
 RW TEMP 26.60 BOD    1.0 SS   20.0 PB 0.0067 HARD   15.0 ALK   10.0 PH 7.00
 COST FACTOR 0.8289 CNAT 0.3060


SEQ NO  73 U.A NO.  40102 UA NAME COLUMBUS METRO AL          CSO AREA       0. CSO POP          0.
UA POP    25281. UA SIZE   18.7 70 SMSA POP   238584.
2000 SMSA POP   259600. NO.CSO PTS.   0# DAYS W/ RAIN  110.0 MEAN RAIN 48.67
 RW CLASS  5 FLOW  67600. % DRAINED 100.00
 RW TEMP 26.60 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 7.00
 COST FACTOR 0.8289 CNAT 0.3060


SEQ NO  74 U.A NO.  40103 UA NAME GADSDEN AL                 CSO AREA       0. CSO POP          0.
UA POP    67706. UA SIZE   55.2 70 SMSA POP    94144.
2000 SMSA POP   122100. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 54.95
 RW CLASS  5 FLOW   9468. % DRAINED 100.00
 RW TEMP 26.00 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 7.00
 COST FACTOR 0.8289 CNAT 0.3060


SEQ NO  75 U.A NO.  40104 UA NAME HUNTSVILLE AL              CSO AREA       0. CSO POP          0.
UA POP   146565. UA SIZE  123.1 70 SMSA POP   282450.
2000 SMSA POP   400400. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 52.07
 RW CLASS  5 FLOW      0. % DRAINED 100.00
 RW TEMP 26.00 BOD    1.0 SS   20.0 PB 0.0117 HARD   35.0 ALK   20.0 PH 7.20
 COST FACTOR 0.8289 CNAT 0.4130


SEQ NO  76 U.A NO.  40105 UA NAME MOBILE AL                  CSO AREA       0. CSO POP          0.
UA POP   257816. UA SIZE  168.4 70 SMSA POP   376690.
2000 SMSA POP   472700. NO.CSO PTS.   0# DAYS W/ RAIN  123.0 MEAN RAIN 67.57
 RW CLASS  1 FLOW     20. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 7.00
 COST FACTOR 0.8289 CNAT 0.3060


SEQ NO  77 U.A NO.  40106 UA NAME MONTGOMERY AL              CSO AREA       0. CSO POP          0.
UA POP   138983. UA SIZE   51.1 70 SMSA POP   225911.
2000 SMSA POP   252800. NO.CSO PTS.   0# DAYS W/ RAIN  113.0 MEAN RAIN 53.66
 RW CLASS  4 FLOW  15100. % DRAINED 100.00
 RW TEMP 26.60 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 7.00
 COST FACTOR 0.8289 CNAT 0.3060
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URBANIZED AREA DATA BASE LISTING

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SEQ NO  78 U.A NO.  40107 UA NAME TUSCALOOSA AL            CSO AREA       0. CSO POP          0.
UA POP    85875. UA SIZE   43.7 70 SMSA POP   116029.
2000 SMSA POP   159000. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 52.77
 RW CLASS  6 FLOW   7868. % DRAINED 100.00
 RW TEMP 26.60 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 7.00
 COST FACTOR 0.8289 CNAT 0.3060


SEQ NO 298 U.A NO.  40108 UA NAME FLORENCE AL              CSO AREA       0. CSO POP          0.
UA POP    62926. UA SIZE   42.0 70 SMSA POP   117743.
2000 SMSA POP   174100. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 49.92
 RW CLASS  5 FLOW  51600. % DRAINED 100.00
 RW TEMP 26.70 BOD    1.0 SS   48.0 PB 0.0067 HARD   50.0 ALK   50.0 PH 7.40
 COST FACTOR 0.8289 CNAT 0.4130


SEQ NO 303 U.A NO.  40109 UA NAME ANNISTON AL              CSO AREA       0. CSO POP          0.
UA POP    58851. UA SIZE   37.4 70 SMSA POP   103092.
2000 SMSA POP   145000. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 51.48
 RW CLASS  2 FLOW     49. % DRAINED 100.00
 RW TEMP 26.00 BOD    0.5 SS   20.0 PB 0.0117 HARD   20.0 ALK   10.0 PH 7.20
 COST FACTOR 0.8289 CNAT 0.3060


SEQ NO 294 U.A NO. 100201 UA NAME ANCHORAGE AK             CSO AREA       0. CSO POP          0.
UA POP   110782. UA SIZE   54.5 70 SMSA POP   126385.
2000 SMSA POP   299500. NO.CSO PTS.   0# DAYS W/ RAIN  126.0 MEAN RAIN 14.71
 RW CLASS  1 FLOW     18. % DRAINED 100.00
 RW TEMP  6.50 BOD    0.0 SS    0.0 PB 0.0    HARD   88.0 ALK    0.0 PH 7.10
 COST FACTOR 1.0330 CNAT 0.0


SEQ NO 258 U.A NO.  90401 UA NAME PHOENIX AZ               CSO AREA       0. CSO POP          0.
UA POP   863357. UA SIZE  387.5 70 SMSA POP   971228.
2000 SMSA POP  1886400. NO.CSO PTS.   0# DAYS W/ RAIN   34.0 MEAN RAIN  7.42
 RW CLASS  2 FLOW     29. % DRAINED 100.00
 RW TEMP 32.10 BOD    0.5 SS   16.0 PB 0.0267 HARD   90.0 ALK   75.0 PH 7.50
 COST FACTOR 0.8843 CNAT 0.0850


SEQ NO 259 U.A NO.  90402 UA NAME TUCSON AZ                CSO AREA       0. CSO POP          0.
UA POP   294184. UA SIZE  104.7 70 SMSA POP   351667.
2000 SMSA POP   560700. NO.CSO PTS.   0# DAYS W/ RAIN   50.0 MEAN RAIN 10.47
 RW CLASS  4 FLOW     21. % DRAINED 100.00
 RW TEMP 32.10 BOD    0.5 SS   16.0 PB 0.0300 HARD   75.0 ALK   75.0 PH 7.50
 COST FACTOR 0.8843 CNAT 0.0850
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URBANIZED AREA DATA BASE LISTING

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SEQ NO 185 U.A NO.  60501 UA NAME FORT SMITH AR                 CSO AREA       0. CSO POP        0.
UA POP    73419. UA SIZE   57.6 70 SMSA POP   160421.
2000 SMSA POP   213800. NO.CSO PTS.   0# DAYS W/ RAIN   93.0 MEAN RAIN 42.22
 RW CLASS  4 FLOW    513. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   80.0 PB 0.0167 HARD   20.0 ALK   75.0 PH 7.80
 COST FACTOR 0.8289 CNAT 0.3300


SEQ NO 186 U.A NO.  60502 UA NAME LITTLE ROCK AR                CSO AREA       0. CSO POP        0.
UA POP   222616. UA SIZE   95.3 70 SMSA POP   323296.
2000 SMSA POP   511600. NO.CSO PTS.   0# DAYS W/ RAIN  102.0 MEAN RAIN 48.66
 RW CLASS  4 FLOW  86333. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   80.0 PB 0.0067 HARD   20.0 ALK   65.0 PH 7.50
 COST FACTOR 0.8289 CNAT 0.3300


SEQ NO 187 U.A NO.  60503 UA NAME PINE BLUFF AR                 CSO AREA       0. CSO POP        0.
UA POP    60907. UA SIZE   20.8 70 SMSA POP    85329.
2000 SMSA POP   112200. NO.CSO PTS.   0# DAYS W/ RAIN  102.0 MEAN RAIN 52.13
 RW CLASS  4 FLOW  86333. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   80.0 PB 0.0067 HARD   20.0 ALK   65.0 PH 7.50
 COST FACTOR 0.8289 CNAT 0.3300


SEQ NO 188 U.A NO.  60504 UA NAME TEXARKANA METRO AR            CSO AREA       0. CSO POP        0.
UA POP    21682. UA SIZE    6.8 70 SMSA POP   113488.
2000 SMSA POP   130300. NO.CSO PTS.   0# DAYS W/ RAIN   98.0 MEAN RAIN 49.19
 RW CLASS  2 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   80.0 PB 0.0117 HARD   78.0 ALK   50.0 PH 7.50
 COST FACTOR 0.8289 CNAT 0.3300


SEQ NO 260 U.A NO.  90601 UA NAME BAKERSFIELD CA                CSO AREA       0. CSO POP        0.
UA POP   176155. UA SIZE   57.2 70 SMSA POP   330234.
2000 SMSA POP   371900. NO.CSO PTS.   0# DAYS W/ RAIN   37.0 MEAN RAIN  6.36
 RW CLASS  3 FLOW    946. % DRAINED 100.00
 RW TEMP 29.30 BOD    0.5 SS   12.0 PB 0.0167 HARD   50.0 ALK   40.0 PH 7.50
 COST FACTOR 1.0578 CNAT 0.0880


SEQ NO 261 U.A NO.  90602 UA NAME FRESNO CA                     CSO AREA       0. CSO POP        0.
UA POP   262908. UA SIZE   79.1 70 SMSA POP   413329.
2000 SMSA POP   455400. NO.CSO PTS.   0# DAYS W/ RAIN   43.0 MEAN RAIN 11.14
 RW CLASS  2 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    0.5 SS    8.0 PB 0.0117 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CNAT 0.4590
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SEQ NO 262 U.A NO.  90603 UA NAME LOS ANGELES CA            CSO AREA       0. CSO POP          0.
UA POP  8351265. UA SIZE 1571.9 70 SMSA POP  6930400.
2000 SMSA POP  9115700. NO.CSO PTS.   0# DAYS W/ RAIN   35.0 MEAN RAIN 14.68
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0167 HARD   35.0 ALK   35.0 PH 7.50
 COST FACTOR 1.0578 CNAT 0.4590


SEQ NO 263 U.A NO.  90604 UA NAME MODESTA CA                CSO AREA       0. CSO POP          0.
UA POP   106107. UA SIZE   34.3 70 SMSA POP   194506.
2000 SMSA POP   251300. NO.CSO PTS.   0# DAYS W/ RAIN   63.0 MEAN RAIN 12.17
 RW CLASS  5 FLOW   1363. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CNAT 0.4590


SEQ NO 264 U.A NO.  90605 UA NAME OXNARD CA                 CSO AREA       0. CSO POP          0.
UA POP   244653. UA SIZE  111.5 70 SMSA POP   378497.
2000 SMSA POP   548800. NO.CSO PTS.   0# DAYS W/ RAIN   35.0 MEAN RAIN 14.75
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0167 HARD   35.0 ALK   35.0 PH 7.50
 COST FACTOR 1.0578 CNAT 0.4590


SEQ NO 265 U.A NO.  90606 UA NAME SACRAMENTO CA             CSO AREA    6800. CSO POP      96119.
UA POP   633732. UA SIZE  244.2 70 SMSA POP   803793.
2000 SMSA POP  1094300. NO.CSO PTS.   3# DAYS W/ RAIN   57.0 MEAN RAIN 18.02
 RW CLASS  5 FLOW  24330. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.0855 CNAT 0.4590


SEQ NO 266 U.A NO.  90607 UA NAME SALINAS CA                CSO AREA       0. CSO POP          0.
UA POP    62456. UA SIZE   15.0 70 SMSA POP   247450.
2000 SMSA POP   312700. NO.CSO PTS.   0# DAYS W/ RAIN   62.0 MEAN RAIN 14.14
 RW CLASS 11 FLOW      0. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.5 SS    8.0 PB 0.0250 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CNAT 0.4590


SEQ NO 267 U.A NO.  90608 UA NAME SAN BERNARDINO CA         CSO AREA       0. CSO POP          0.
UA POP   583597. UA SIZE  309.7 70 SMSA POP  1141307.
2000 SMSA POP  1602400. NO.CSO PTS.   0# DAYS W/ RAIN   35.0 MEAN RAIN 17.71
 RW CLASS  3 FLOW      8. % DRAINED 100.00
 RW TEMP 32.10 BOD    0.5 SS   18.0 PB 0.0250 HARD  100.0 ALK  100.0 PH 7.50
 COST FACTOR 1.0578 CNAT 0.0880
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SEQ NO 268 U.A NO.  90609 UA NAME SAN DIEGO CA            CSO AREA       0. CSO POP        0.
UA POP  1198322. UA SIZE  380.7 70 SMSA POP  1357854.
2000 SMSA POP  1976000. NO.CSO PTS.   0# DAYS W/ RAIN   42.0 MEAN RAIN 10.40
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 19.90 BOD    0.5 SS   10.0 PB 0.0250 HARD   50.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0768 CRAT 0.4590


SEQ NO 269 U.A NO.  90610 UA NAME SAN FRANCISCO CA        CSO AREA   28550. CSO POP   731000.
UA POP  2987849. UA SIZE  681.0 70 SMSA POP  3107355.
2000 SMSA POP  4155300. NO.CSO PTS.  39# DAYS W/ RAIN   67.0 MEAN RAIN 20.78
 RW CLASS 12 FLOW      0. % DRAINED 100.00
 RW TEMP 15.40 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CRAT 0.4590


SEQ NO 270 U.A NO.  90611 UA NAME SAN JOSE CA             CSO AREA       0. CSO POP        0.
UA POP  1025273. UA SIZE  277.2 70 SMSA POP  1065313.
2000 SMSA POP  1954000. NO.CSO PTS.   0# DAYS W/ RAIN   63.0 MEAN RAIN 13.11
 RW CLASS  2 FLOW     45. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CRAT 0.4590


SEQ NO 271 U.A NO.  90612 UA NAME SANTA BARBARA CA        CSO AREA       0. CSO POP        0.
UA POP   129774. UA SIZE   37.1 70 SMSA POP   264324.
2000 SMSA POP   386400. NO.CSO PTS.   0# DAYS W/ RAIN   35.0 MEAN RAIN 17.63
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 17.70 BOD    0.5 SS    8.0 PB 0.0150 HARD   30.0 ALK   35.0 PH 7.50
 COST FACTOR 1.0578 CRAT 0.4590


SEQ NO 272 U.A NO.  90613 UA NAME SANTA ROSA CA           CSO AREA       0. CSO POP        0.
UA POP    75083. UA SIZE   38.2 70 SMSA POP   204885.
2000 SMSA POP   252500. NO.CSO PTS.   0# DAYS W/ RAIN   67.0 MEAN RAIN 29.25
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 15.40 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.0855 CRAT 0.4590


SEQ NO 273 U.A NO.  90614 UA NAME SEASIDE CA              CSO AREA       0. CSO POP        0.
UA POP    93284. UA SIZE   24.1 70 SMSA POP   247450.
2000 SMSA POP   312700. NO.CSO PTS.   0# DAYS W/ RAIN   62.0 MEAN RAIN 14.14
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.5 SS    8.0 PB 0.0250 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CRAT 0.4590
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SEQ NO 274 U.A NO.  90615 UA NAME SIMI VALLEY CA          CSO AREA      0. CSO POP        0.
UA POP    56536. UA SIZE   24.8 70 SMSA POP   378497.
2000 SMSA POP   548800. NO.CSO PTS.   0# DAYS W/ RAIN   35.0 MEAN RAIN 14.22
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0167 HARD   35.0 ALK   35.0 PH 7.50
 COST FACTOR 1.0578 CRAT 0.4590


SEQ NO 275 U.A NO.  90616 UA NAME STOCKTON CA             CSO AREA      0. CSO POP        0.
UA POP   160373. UA SIZE   46.8 70 SMSA POP   291073.
2000 SMSA POP   333600. NO.CSO PTS.   0# DAYS W/ RAIN   50.0 MEAN RAIN 14.31
 RW CLASS  4 FLOW      0. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CRAT 0.4590


SEQ NO 306 U.A NO.  90617 UA NAME SANTA CRUZ CA           CSO AREA      0. CSO POP        0.
UA POP    73758. UA SIZE   34.4 70 SMSA POP   123790.
2000 SMSA POP   161100. NO.CSO PTS.   0# DAYS W/ RAIN   67.0 MEAN RAIN 31.25
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CRAT 0.4590


SEQ NO 307 U.A NO.  90618 UA NAME ANTIOCH PITTSBURG CA    CSO AREA      0. CSO POP        0.
UA POP    59585. UA SIZE   22.3 70 SMSA POP  3111866.
2000 SMSA POP  4155300. NO.CSO PTS.   0# DAYS W/ RAIN  163.0 MEAN RAIN 13.34
 RW CLASS 11 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.3175 CRAT 0.4590


SEQ NO 246 U.A NO.  80801 UA NAME BOULDER CO              CSO AREA      0. CSO POP        0.
UA POP    68634. UA SIZE   14.1 70 SMSA POP  1239477.
2000 SMSA POP  1981000. NO.CSO PTS.   0# DAYS W/ RAIN   87.0 MEAN RAIN 18.57
 RW CLASS  1 FLOW     89. % DRAINED  90.00
 RW TEMP 18.20 BOD    1.0 SS   80.0 PB 0.0167 HARD   50.0 ALK   90.0 PH 7.50
 COST FACTOR 0.8843 CRAT 0.0720


SEQ NO 247 U.A NO.  80802 UA NAME COLORADO SPRINGS CO     CSO AREA      0. CSO POP        0.
UA POP   204766. UA SIZE   90.0 70 SMSA POP   239288.
2000 SMSA POP   292900. NO.CSO PTS.   0# DAYS W/ RAIN   86.0 MEAN RAIN 13.19
 RW CLASS  1 FLOW     27. % DRAINED 100.00
 RW TEMP 18.20 BOD    1.0 SS   80.0 PB 0.0167 HARD   50.0 ALK   90.0 PH 7.50
 COST FACTOR 0.8843 CRAT 0.0820
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SEQ NO 248 U.A NO.  80803 UA NAME DENVER CC                    CSC AREA       0. CSO POP          0.
UA POP  1047311. UA SIZE  292.8 70 SMSA POP  1239477.
2000 SMSA POP  1981000. NO.CSO PTS.   0# DAYS W/ RAIN   87.0 MEAN RAIN 12.89
 RW CLASS  2 FLOW    342. % DRAINED 100.00
 RW TEMP 18.20 BOD    1.0 SS   80.0 PB 0.0167 HARD   50.0 ALK   90.0 PH 7.50
 COST FACTOR 0.8843 CNAT 0.0720


SEQ NO 249 U.A NO.  80804 UA NAME PUEBLO CC                    CSC AREA     429. CSO POP       1964.
UA POP   103300. UA SIZE   31.5 70 SMSA POP   118238.
2000 SMSA POP   135400. NO.CSO PTS.   0# DAYS W/ RAIN   70.0 MEAN RAIN 11.84
 RW CLASS  2 FLOW      54. % DRAINED 100.00
 RW TEMP 18.20 BOD    1.0 SS   80.0 PB 0.0167 HARD   50.0 ALK   90.0 PH 7.50
 COST FACTOR 0.8843 CNAT 0.0820


SEQ NO   1 U.A NO.  10901 UA NAME BRIDGEPORT CT                CSC AREA    3380. CSO POP     50000.
UA POP   413366. UA SIZE  148.8 70 SMSA POP   792814.
2000 SMSA POP  1080300. NO.CSO PTS.  57# DAYS W/ RAIN  119.0 MEAN RAIN 42.01
 RW CLASS 12 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CNAT 0.5650


SEQ NO   2 U.A NO.  10902 UA NAME BRISTOL CT                   CSC AREA       0. CSO POP          0.
UA POP    71732. UA SIZE   37.3 70 SMSA POP  1035195.
2000 SMSA POP  1096800. NO.CSO PTS.   0# DAYS W/ RAIN  128.0 MEAN RAIN 42.43
 RW CLASS  1 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CNAT 0.5650


SEQ NO   3 U.A NO.  10903 UA NAME DANBURY CT                   CSC AREA       0. CSO POP          0.
UA POP    66651. UA SIZE   54.9 70 SMSA POP   792814.
2000 SMSA POP  1080300. NO.CSO PTS.   0# DAYS W/ RAIN  119.0 MEAN RAIN 42.01
 RW CLASS  1 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CNAT 0.5650


SEQ NO   4 U.A NO.  10904 UA NAME HARTFORD CT                  CSC AREA    3492. CSO POP    114000.
UA POP   465001. UA SIZE  130.5 70 SMSA POP  1035195.
2000 SMSA POP  1096800. NO.CSO PTS. 122# DAYS W/ RAIN  128.0 MEAN RAIN 42.43
 RW CLASS  5 FLOW  16230. % DRAINED  80.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CNAT 0.5650
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SEQ NO   5 U.A NO.  10905 UA NAME MERIDEN CT                CSO AREA       0. CSO POP         0.
UA POP    98454. UA SIZE   70.7 70 SMSA POP   744948.
2000 SMSA POP   976000. NO.CSO PTS.    0# DAYS W/ RAIN  128.0 MEAN RAIN 44.14
 RW CLASS  5 FLOW       0. % DRAINED  60.00
 RW TEMP 21.00 BOD    1.0 SS    20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO   6 U.A NO.  10906 UA NAME NEW BRITAIN CT            CSO AREA       0. CSO POP         0.
UA POP   131349. UA SIZE   39.1 70 SMSA POP  1035195.
2000 SMSA POP  1096800. NO.CSO PTS.    0# DAYS W/ RAIN  128.0 MEAN RAIN 42.43
 RW CLASS  1 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS    20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO   7 U.A NO.  10907 UA NAME NEW HAVEN CT              CSO AREA    3658. CSO POP     84300.
UA POP   348341. UA SIZE  107.3 70 SMSA POP   744948.
2000 SMSA POP   976000. NO.CSO PTS.    0# DAYS W/ RAIN  131.0 MEAN RAIN 44.49
 RW CLASS 13 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS    20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO   8 U.A NO.  10908 UA NAME NORWALK CT                CSO AREA     525. CSO POP     15800.
UA POP   106707. UA SIZE   41.5 70 SMSA POP   792814.
2000 SMSA POP  1080300. NO.CSO PTS.    4# DAYS W/ RAIN  119.0 MEAN RAIN 42.01
 RW CLASS 13 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS    20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO   9 U.A NO.  10909 UA NAME SPRINGFIELD METRO CT      CSO AREA       0. CSO POP         0.
UA POP    58173. UA SIZE   26.7 70 SMSA POP   583031.
2000 SMSA POP   667400. NO.CSO PTS.    0# DAYS W/ RAIN  128.0 MEAN RAIN 45.11
 RW CLASS  5 FLOW   16230. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS    20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO  10 U.A NO.  10910 UA NAME STAMFORD CT               CSO AREA       0. CSO POP         0.
UA POP   184858. UA SIZE   69.6 70 SMSA POP   792814.
2000 SMSA POP  1080300. NO.CSO PTS.    0# DAYS W/ RAIN  119.0 MEAN RAIN 42.01
 RW CLASS 15 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS    20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650
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SEQ NO  11 U.A NO.  10911 UA NAME WATERBURY CT                  CSO AREA     305. CSO POP     6947.
UA POP   156586. UA SIZE   59.9 70 SMSA POP   744948.
2000 SMSA POP    976000. NO.CSO PTS.   4# DAYS W/ RAIN  128.0 MEAN RAIN 47.26
 RW CLASS 13 FLOW    197. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CRAT 0.5650


SEQ NO 290 U.A NO.  10912 UA NAME NEW LONDON-NORWICH CT      CSO AREA    4000. CSO POP    23000.
UA POP   139121. UA SIZE   75.4 70 SMSA POP   230654.
2000 SMSA POP   291300. NO.CSO PTS.  22# DAYS W/ RAIN  128.0 MEAN RAIN 50.88
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.0919 CRAT 0.5650


SEQ NO  44 U.A NO.  31001 UA NAME WILMINGTON DE                 CSO AREA    6936. CSO POP    80368.
UA POP   349674. UA SIZE   97.1 70 SMSA POP   499493.
2000 SMSA POP   712200. NO.CSO PTS.  30# DAYS W/ RAIN  127.0 MEAN RAIN 44.36
 RW CLASS  1 FLOW    465. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.1818 CRAT 0.4620


SEQ NO  45 U.A NO.  31101 UA NAME WASHINGTON DC                 CSO AREA   14713. CSO POP   489093.
UA POP   756510. UA SIZE   61.4 70 SMSA POP  2910111.
2000 SMSA POP  5189600. NO.CSO PTS.  59# DAYS W/ RAIN  111.0 MEAN RAIN 40.78
 RW CLASS 12 FLOW  11190. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 1.0083 CRAT 0.3910


SEQ NO  79 U.A NO.  41201 UA NAME FT LAUDERDALE FL              CSO AREA       0. CSO POP        0.
UA POP   613797. UA SIZE  212.2 70 SMSA POP   620100.
2000 SMSA POP  1472700. NO.CSO PTS.   0# DAYS W/ RAIN  127.0 MEAN RAIN 60.29
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060


SEQ NO  80 U.A NO.  41202 UA NAME GAINESVILLE FL                CSO AREA       0. CSO POP        0.
UA POP    69329. UA SIZE   29.0 70 SMSA POP   104764.
2000 SMSA POP   186600. NO.CSO PTS.   0# DAYS W/ RAIN  116.0 MEAN RAIN 52.45
 RW CLASS  1 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060
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SEQ NO  81 U.A NO.  41203 UA NAME JACKSONVILLE FL            CSO AREA      0. CSO POP        0.
UA POP   529585. UA SIZE  351.3 70 SMSA POP   621827.
2000 SMSA POP   815500. NO.CSO PTS.   0# DAYS W/ RAIN  116.0 MEAN RAIN 53.36
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060


SEQ NO  82 U.A NO.  41204 UA NAME MIAMI FL                   CSO AREA      0. CSO POP        0.
UA POP  1219660. UA SIZE  258.7 70 SMSA POP  1267792.
2000 SMSA POP  2817400. NO.CSO PTS.   0# DAYS W/ RAIN  127.0 MEAN RAIN 57.48
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060


SEQ NO  83 U.A NO.  41205 UA NAME ORLANDO FL                 CSO AREA      0. CSO POP        0.
UA POP   305479. UA SIZE  131.7 70 SMSA POP   453270.
2000 SMSA POP   769000. NO.CSO PTS.   0# DAYS W/ RAIN  114.0 MEAN RAIN 51.37
 RW CLASS  7 FLOW      0. % DRAINED  40.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060


SEQ NO  84 U.A NO.  41206 UA NAME PENSACOLA FL               CSO AREA      0. CSO POP        0.
UA POP   166619. UA SIZE   66.4 70 SMSA POP   243075.
2000 SMSA POP   295000. NO.CSO PTS.   0# DAYS W/ RAIN  118.0 MEAN RAIN 62.87
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060


SEQ NO  85 U.A NO.  41207 UA NAME ST PETERSBURG FL           CSO AREA      0. CSO POP        0.
UA POP   495159. UA SIZE  160.5 70 SMSA POP  1088549.
2000 SMSA POP  1955500. NO.CSO PTS.   0# DAYS W/ RAIN  108.0 MEAN RAIN 55.41
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060


SEQ NO  86 U.A NO.  41208 UA NAME TALLAHASSEE FL             CSO AREA      0. CSO POP        0.
UA POP    77851. UA SIZE   29.8 70 SMSA POP   109355.
2000 SMSA POP   196000. NO.CSO PTS.   0# DAYS W/ RAIN  119.0 MEAN RAIN 56.86
 RW CLASS  6 FLOW      0. % DRAINED  80.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CRAT 0.3060
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SEQ NO  87 U.A NO.  41209 UA NAME TAMPA FL                  CSO AREA       0. CSO POP        0.
UA POP   368742. UA SIZE  130.5 70 SMSA POP  1088549.
2000 SMSA POP  1955500. NO.CSO PTS.   0# DAYS W/ RAIN  108.0 MEAN RAIN 51.57
 RW CLASS 10 FLOW     107. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CHAT 0.3060


SEQ NO  88 U.A NO.  41210 UA NAME WEST PALM BEACH FL        CSO AREA       0. CSO POP        0.
UA POP   287561. UA SIZE  136.4 70 SMSA POP   348993.
2000 SMSA POP   650200. NO.CSO PTS.   0# DAYS W/ RAIN  131.0 MEAN RAIN 61.70
 RW CLASS 15 FLOW       0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CHAT 0.3060


SEQ NO 287 U.A NO.  41211 UA NAME MELBOURNE COCOA FL        CSO AREA       0. CSO POP        0.
UA POP   178948. UA SIZE  106.8 70 SMSA POP   230006.
2000 SMSA POP   473000. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 55.96
 RW CLASS 15 FLOW       0. % DRAINED 100.00
 RW TEMP 28.80 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CHAT 0.3060


SEQ NO 288 U.A NO.  41212 UA NAME SARASOTA-BRADENTON FL    CSO AREA       0. CSO POP        0.
UA POP   167298. UA SIZE   91.6 70 SMSA POP   217528.
2000 SMSA POP   450774. NO.CSO PTS.   0# DAYS W/ RAIN  108.0 MEAN RAIN 55.41
 RW CLASS 15 FLOW       0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CHAT 0.3060


SEQ NO 289 U.A NO.  41213 UA NAME DAYTONA BEACH FL          CSO AREA       0. CSO POP        0.
UA POP   115176. UA SIZE   85.0 70 SMSA POP   169487.
2000 SMSA POP   247900. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 49.90
 RW CLASS 15 FLOW       0. % DRAINED 100.00
 RW TEMP 28.80 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CHAT 0.3060


SEQ NO 297 U.A NO.  41214 UA NAME FORT MYERS FL             CSO AREA       0. CSO POP        0.
UA POP    69129. UA SIZE   43.4 70 SMSA POP   105216.
2000 SMSA POP   265300. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 53.34
 RW CLASS 11 FLOW       0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CHAT 0.3060
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                                                              CSC AREA       0. CSO POP        0.
SEQ NO 310 U.A NO.  41215 UA NAME LAKELAND FL
UA POP    66739. UA SIZE   27.3 70 SMSA POP   228515.
2000 SMSA POP   381700. NO.CSO PTS.   0# DAYS W/ RAIN  121.0 MEAN RAIN 51.37
 RW CLASS  7 FLOW       0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   20.0 PB 0.0117 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8843 CNAT 0.3060


                                                              CSC AREA     225. CSO POP     6000.
SEQ NO  89 U.A NO.  41301 UA NAME ALBANY GA
UA POP    76512. UA SIZE   32.9 70 SMSA POP    96683.
2000 SMSA POP   118000. NO.CSO PTS.   0# DAYS W/ RAIN  110.0 MEAN RAIN 47.84
 RW CLASS  5 FLOW    6339. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8347 CNAT 0.3060


                                                              CSC AREA   11290. CSO POP   115800.
SEQ NO  90 U.A NO.  41302 UA NAME ATLANTA GA
UA POP  1172777. UA SIZE  435.0 70 SMSA POP  1595517.
2000 SMSA POP  2465300. NO.CSO PTS.   6# DAYS W/ RAIN  115.0 MEAN RAIN 47.14
 RW CLASS  5 FLOW    2742. % DRAINED  70.00
 RW TEMP 26.70 BOD    1.0 SS   20.0 PB 0.0067 HARD   15.0 ALK   10.0 PH 6.90
 COST FACTOR 0.8347 CNAT 0.3060


                                                              CSC AREA    8960. CSO POP    54863.
SEQ NO  91 U.A NO.  41303 UA NAME AUGUSTA GA
UA POP   126770. UA SIZE   42.4 70 SMSA POP   275787.
2000 SMSA POP   277400. NO.CSO PTS.   4# DAYS W/ RAIN  105.0 MEAN RAIN 39.18
 RW CLASS  5 FLOW   10200. % DRAINED 100.00
 RW TEMP 26.70 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.40
 COST FACTOR 0.8347 CNAT 0.3060


SEQ NO  92 U.A NO.  41304 UA NAME CHATTANOOGA METRO GA    CSC AREA       0. CSO POP        0.
UA POP    28947. UA SIZE   17.2 70 SMSA POP   370857.
2000 SMSA POP   484200. NO.CSO PTS.   0# DAYS W/ RAIN  131.0 MEAN RAIN 53.60
 RW CLASS  4 FLOW   37180. % DRAINED 100.00
 RW TEMP 25.40 BOD    0.5 SS   20.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 7.10
 COST FACTOR 0.8347 CNAT 0.3060


                                                              CSC AREA    3064. CSO POP    22970.
SEQ NO  93 U.A NO.  41305 UA NAME COLUMBUS GA
UA POP   183335. UA SIZE   87.5 70 SMSA POP   238534.
2000 SMSA POP   259600. NO.CSO PTS.  15# DAYS W/ RAIN  110.0 MEAN RAIN 48.67
 RW CLASS  5 FLOW    6760. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   20.0 PB 0.0147 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.8347 CNAT 0.3060
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SEQ NO  94 U.A NO.  41306 UA NAME MACON GA                       CSO AREA       0. CSO POP        0.
UA POP   128065. UA SIZE   51.3 70 SMSA POP   226782.
2000 SMSA POP   299600. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 44.08
 RW CLASS  4 FLOW   2740. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.8347 CRAT 0.3060


SEQ NO  95 U.A NO.  41307 UA NAME SAVANNAH GA                    CSO AREA    1184. CSO POP    18210.
UA POP   163753. UA SIZE   64.1 70 SMSA POP   207987.
2000 SMSA POP   208900. NO.CSO PTS.   0# DAYS W/ RAIN  110.0 MEAN RAIN 48.91
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.8347 CRAT 0.3060


SEQ NO 276 U.A NO.  91501 UA NAME HONOLULU HI                    CSO AREA       0. CSO POP        0.
UA POP   442397. UA SIZE  115.0 70 SMSA POP   630528.
2000 SMSA POP   952500. NO.CSO PTS.   0# DAYS W/ RAIN   99.0 MEAN RAIN 23.96
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 20.40 BOD    0.0 SS   62.3 PB 0.0    HARD   37.5 ALK   32.0 PH 7.90
 COST FACTOR 1.7000 CRAT 0.0


SEQ NO 279 U.A NO. 101601 UA NAME BOISE CITY ID                  CSO AREA       0. CSO POP        0.
UA POP    85187. UA SIZE   29.4 70 SMSA POP   112230.
2000 SMSA POP   146700. NO.CSO PTS.   0# DAYS W/ RAIN   91.0 MEAN RAIN 11.43
 RW CLASS  3 FLOW   1383. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.5 SS   12.0 PB 0.0067 HARD   35.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CRAT 0.5300


SEQ NO 121 U.A NO.  51701 UA NAME AURORA IL                      CSO AREA    7170. CSO POP   148200.
UA POP   232917. UA SIZE   76.8 70 SMSA POP  6977611.
2000 SMSA POP  8934600. NO.CSO PTS.  33# DAYS W/ RAIN  120.0 MEAN RAIN 33.80
 RW CLASS  3 FLOW    808. % DRAINED 100.00
 RW TEMP 23.80 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.1009 CRAT 0.2350


SEQ NO 122 U.A NO.  51702 UA NAME BLOOMINGTON IL                 CSO AREA    2010. CSO POP    41200.
UA POP    69392. UA SIZE   19.9 70 SMSA POP   104389.
2000 SMSA POP   144200. NO.CSO PTS.  10# DAYS W/ RAIN  109.0 MEAN RAIN 36.20
 RW CLASS  2 FLOW     42. % DRAINED  90.00
 RW TEMP 23.80 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.2209 CRAT 0.2350
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SEQ NO 123 U.A NO.  51703 UA NAME CHAMPAIGN IL            CSO AREA       0. CSO POP        0.
UA POP   100417. UA SIZE   18.3 70 SMSA POP   163281.
2000 SMSA POP   210700. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 37.00
 RW CLASS  1 FLOW      0. % DRAINED  20.00
 RW TEMP 23.80 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  175.0 PH 8.00
 COST FACTOR 1.2209 CMAT 0.2350


SEQ NO 124 U.A NO.  51704 UA NAME CHICAGO IL              CSO AREA  231608. CSO POP  4508725.
UA POP  6185152. UA SIZE  978.1 70 SMSA POP  6977611.
2000 SMSA POP  8934600. NO.CSO PTS. 680# DAYS W/ RAIN  120.0 MEAN RAIN 33.49
 RW CLASS  6 FLOW    568. % DRAINED 100.00
 RW TEMP 22.70 BOD    3.0 SS    7.0 PB 0.0167 HARD  200.0 ALK  150.0 PH 8.00
 COST FACTOR 1.2209 CMAT 0.2350


SEQ NO 125 U.A NO.  51705 UA NAME DAVENPORT METRO IL      CSO AREA       0. CSO POP        0.
UA POP   139824. UA SIZE   35.3 70 SMSA POP   362638.
2000 SMSA POP   396900. NO.CSO PTS.   0# DAYS W/ RAIN  110.0 MEAN RAIN 33.88
 RW CLASS  5 FLOW  50000. % DRAINED 100.00
 RW TEMP 23.80 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8336 CMAT 0.2350


SEQ NO 126 U.A NO.  51706 UA NAME DECATUR IL              CSO AREA    5800. CSO POP    40000.
UA POP    99693. UA SIZE   37.2 70 SMSA POP   125010.
2000 SMSA POP   194800. NO.CSO PTS.   6# DAYS W/ RAIN  112.0 MEAN RAIN 37.13
 RW CLASS  1 FLOW    331. % DRAINED 100.00
 RW TEMP 24.30 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.1009 CMAT 0.2350


SEQ NO 127 U.A NO.  51707 UA NAME DUBUQUE METRO IL        CSO AREA       0. CSO POP        0.
UA POP     2408. UA SIZE    1.9 70 SMSA POP    90609.
2000 SMSA POP   106500. NO.CSO PTS.   0# DAYS W/ RAIN  109.0 MEAN RAIN 35.71
 RW CLASS  5 FLOW  50000. % DRAINED 100.00
 RW TEMP 22.70 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.80
 COST FACTOR 0.8336 CMAT 0.2350


SEQ NO 128 U.A NO.  51708 UA NAME JOLIET IL               CSO AREA   11076. CSO POP    94337.
UA POP   155500. UA SIZE   55.0 70 SMSA POP  6977611.
2000 SMSA POP  8934600. NO.CSO PTS.  37# DAYS W/ RAIN  120.0 MEAN RAIN 33.80
 RW CLASS  3 FLOW     83. % DRAINED 100.00
 RW TEMP 24.30 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  175.0 PH 8.00
 COST FACTOR 1.1009 CMAT 0.2350
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SEQ NO 129 U.A NO.  51709 UA NAME PEORIA IL                  CSC AREA    4100. CSO POP   106000.
UA POP   247121. UA SIZE  106.7 70 SMSA POP   341979.
2000 SMSA POP   443100. NO.CSO PTS.  23# DAYS W/ RAIN  109.0 MEAN RAIN 34.84
 RW CLASS  4 FLOW  14427. % DRAINED 100.00
 RW TEMP 24.30 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.2209 CNAT 0.2350


SEQ NO 130 U.A NO.  51710 UA NAME ROCKFORD IL                CSC AREA       0. CSO POP        0.
UA POP   206084. UA SIZE   61.0 70 SMSA POP   272063.
2000 SMSA POP   337900. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 35.62
 RW CLASS  3 FLOW   8588. % DRAINED 100.00
 RW TEMP 22.70 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  190.0 PH 7.80
 COST FACTOR 1.2209 CNAT 0.2350


SEQ NO 131 U.A NO.  51711 UA NAME SPRINGFIELD IL             CSC AREA   12100. CSO POP    75000.
UA POP   120794. UA SIZE   33.5 70 SMSA POP   171020.
2000 SMSA POP   255900. NO.CSO PTS.   7# DAYS W/ RAIN  112.0 MEAN RAIN 34.83
 RW CLASS  3 FLOW      0. % DRAINED 100.00
 RW TEMP 24.30 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.1009 CNAT 0.2350


SEQ NO 132 U.A NO.  51712 UA NAME ST LOUIS METRO IL          CSC AREA   11080. CSO POP    88322.
UA POP   314476. UA SIZE  114.7 70 SMSA POP  2410602.
2000 SMSA POP  2825200. NO.CSO PTS.   6# DAYS W/ RAIN  104.0 MEAN RAIN 36.46
 RW CLASS  5 FLOW 176800. % DRAINED 100.00
 RW TEMP 24.90 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  180.0 PH 8.00
 COST FACTOR 1.1009 CNAT 0.2350


SEQ NO 299 U.A NO.  51713 UA NAME ALTON IL                   CSC AREA    1600. CSO POP    39700.
UA POP    95998. UA SIZE   41.5 70 SMSA POP  2410602.
2000 SMSA POP  2825200. NO.CSO PTS.   2# DAYS W/ RAIN  104.0 MEAN RAIN 41.22
 RW CLASS  4 FLOW  97560. % DRAINED 100.00
 RW TEMP 23.80 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.1009 CNAT 0.2350


SEQ NO 133 U.A NO.  51801 UA NAME ANDERSON IN                CSC AREA    7840. CSO POP    23375.
UA POP    80704. UA SIZE   43.4 70 SMSA POP   138522.
2000 SMSA POP   156700. NO.CSO PTS.  46# DAYS W/ RAIN  124.0 MEAN RAIN 36.71
 RW CLASS  5 FLOW    365. % DRAINED 100.00
 RW TEMP 23.70 BOD    2.8 SS   20.0 PB 0.0167 HARD  200.0 ALK  120.0 PH 8.00
 COST FACTOR 1.1411 CNAT 0.3860
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SEQ NO 134 U.A NO.  51802 UA NAME CHICAGO METRO IN          CSC AREA   73935. CSO POP   469363.
UA POP   529422. UA SIZE  299.1 70 SMSA POP  6977611.
2000 SMSA POP  8934600. NO.CSO PTS. 127# DAYS W/ RAIN  120.0 MEAN RAIN 33.49
 BW CLASS  6 FLOW       0. % DRAINED 100.00
 BW TEMP 23.20 BOD    2.8 SS   20.0 PB 0.0167 HARD  200.0 ALK  150.0 PH 7.70
 COST FACTOR 1.2209 CMAT 0.3860


SEQ NO 135 U.A NO.  51803 UA NAME EVANSVILLE IN             CSC AREA   14780. CSO POP    50425.
UA POP   142476. UA SIZE   40.5 70 SMSA POP   284959.
2000 SMSA POP   326100. NO.CSO PTS.  25# DAYS W/ RAIN  115.0 MEAN RAIN 41.37
 BW CLASS  5 FLOW 133300. % DRAINED 100.00
 BW TEMP 24.90 BOD    3.0 SS   20.0 PB 0.0167 HARD  200.0 ALK    0.0 PH 8.00
 COST FACTOR 1.1411 CMAT 0.3860


SEQ NO 136 U.A NO.  51804 UA NAME FORT WAYNE IN             CSC AREA   12320. CSO POP   183548.
UA POP   225184. UA SIZE   69.0 70 SMSA POP   361984.
2000 SMSA POP   442200. NO.CSO PTS.  43# DAYS W/ RAIN  129.0 MEAN RAIN 34.21
 BW CLASS  4 FLOW   1393. % DRAINED 100.00
 BW TEMP 23.20 BOD    2.1 SS   20.0 PB 0.0167 HARD  150.0 ALK  100.0 PH 7.80
 COST FACTOR 1.1411 CMAT 0.3860


SEQ NO 137 U.A NO.  51805 UA NAME INDIANAPOLIS IN           CSC AREA   35200. CSO POP   529073.
UA POP   820259. UA SIZE  381.2 70 SMSA POP  1111352.
2000 SMSA POP  1540400. NO.CSO PTS. 114# DAYS W/ RAIN  124.0 MEAN RAIN 39.69
 BW CLASS  4 FLOW   1388. % DRAINED 100.00
 BW TEMP 24.30 BOD    3.0 SS  100.0 PB 0.0167 HARD  200.0 ALK  140.0 PH 8.00
 COST FACTOR 1.1411 CMAT 0.3860


SEQ NO 138 U.A NO.  51806 UA NAME LAFAYETTE IN              CSC AREA    7450. CSO POP    69805.
UA POP    79117. UA SIZE   18.6 70 SMSA POP   109378.
2000 SMSA POP   139600. NO.CSO PTS.  18# DAYS W/ RAIN  124.0 MEAN RAIN 36.06
 BW CLASS  4 FLOW   6167. % DRAINED 100.00
 BW TEMP 23.70 BOD    2.9 SS   20.0 PB 0.0167 HARD  200.0 ALK  150.0 PH 8.00
 COST FACTOR 1.1148 CMAT 0.3860


SEQ NO 139 U.A NO.  51807 UA NAME LOUISVILLE METRO IN       CSC AREA       0. CSO POP        0.
UA POP    81488. UA SIZE   26.6 70 SMSA POP   267330.
2000 SMSA POP  1297100. NO.CSO PTS.   0# DAYS W/ RAIN  122.0 MEAN RAIN 41.37
 BW CLASS  5 FLOW 113600. % DRAINED 100.00
 BW TEMP 24.30 BOD    3.0 SS   20.0 PB 0.0167 HARD  200.0 ALK  100.0 PH 8.00
 COST FACTOR 1.1411 CMAT 0.3860
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SEQ NO 140 U.A NO.  51808 UA NAME MUNCIE IN               CSC AREA    4800. CSO POP    54400.
UA POP    90427. UA SIZE   24.5 70 SMSA POP   129219.
2000 SMSA POP   147800. NO.CSO PTS.  42# DAYS W/ RAIN  124.0 MEAN RAIN 39.11
 RW CLASS  3 FLOW    213. % DRAINED 100.00
 RW TEMP 23.70 BOD    2.2 SS   20.0 PB 0.0167 HARD  150.0 ALK  100.0 PH 8.00
 COST FACTOR 1.1411 CMAT 0.3860


SEQ NO 141 U.A NO.  51809 UA NAME SOUTH BEND IN           CSC AREA   36438. CSO POP   176768.
UA POP   265148. UA SIZE   89.2 70 SMSA POP   280031.
2000 SMSA POP   327900. NO.CSO PTS. 125# DAYS W/ RAIN  136.0 MEAN RAIN 35.59
 RW CLASS  4 FLOW  29140. % DRAINED 100.00
 RW TEMP 22.10 BOD    2.0 SS   88.0 PB 0.0167 HARD  200.0 ALK  130.0 PH 7.80
 COST FACTOR 1.0577 CMAT 0.2350


SEQ NO 142 U.A NO.  51810 UA NAME TERRA HAUTE IN          CSC AREA    3405. CSO POP    10152.
UA POP    80908. UA SIZE   31.6 70 SMSA POP   175143.
2000 SMSA POP   198700. NO.CSO PTS.  10# DAYS W/ RAIN  124.0 MEAN RAIN 41.66
 RW CLASS  3 FLOW  38822. % DRAINED 100.00
 RW TEMP 24.30 BOD    3.0 SS  100.0 PB 0.0167 HARD  200.0 ALK  140.0 PH 8.00
 COST FACTOR 1.1148 CMAT 0.3860


SEQ NO 227 U.A NO.  71901 UA NAME CEDAR RAPIDS IA         CSC AREA       0. CSO POP        0.
UA POP   132008. UA SIZE   62.0 70 SMSA POP   163213.
2000 SMSA POP   207500. NO.CSO PTS.   0# DAYS W/ RAIN   91.0 MEAN RAIN 33.82
 RW CLASS  2 FLOW   3262. % DRAINED 100.00
 RW TEMP 23.20 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.70
 COST FACTOR 0.8336 CMAT 0.2350


SEQ NO 228 U.A NO.  71902 UA NAME DAVENPORT IA            CSC AREA    1000. CSO POP    60000.
UA POP   126295. UA SIZE   82.9 70 SMSA POP   362638.
2000 SMSA POP   396900. NO.CSO PTS.  10# DAYS W/ RAIN  110.0 MEAN RAIN 33.88
 RW CLASS  5 FLOW  50000. % DRAINED 100.00
 RW TEMP 23.80 BOD    3.0 SS  120.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8336 CMAT 0.2350


SEQ NO 229 U.A NO.  71903 UA NAME DES MOINES IA           CSC AREA    2793. CSO POP   100000.
UA POP   255824. UA SIZE  109.1 70 SMSA POP   313562.
2000 SMSA POP   391100. NO.CSO PTS.  20# DAYS W/ RAIN  105.0 MEAN RAIN 31.06
 RW CLASS  3 FLOW   4645. % DRAINED 100.00
 RW TEMP 23.80 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.70
 COST FACTOR 0.8371 CMAT 0.2350
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SEQ NO 230 U.A NO.  71904 UA NAME DUBUQUE IA                CSO AREA       0. CSO POP        0.
UA POP    63143. UA SIZE   17.2 70 SMSA POP    90609.
2000 SMSA POP   106500. NO.CSO PTS.   0# DAYS W/ RAIN  109.0 MEAN RAIN 35.71
 RW CLASS  5 FLOW  50000. % DRAINED 100.00
 RW TEMP 23.20 BOD    3.0 SS  120.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.70
 COST FACTOR 0.8336 CNAT 0.2350


SEQ NO 231 U.A NO.  71905 UA NAME OMAHA METRO IA            CSO AREA       0. CSO POP        0.
UA POP    64847. UA SIZE   41.0 70 SMSA POP   542646.
2000 SMSA POP   694100. NO.CSO PTS.   0# DAYS W/ RAIN   94.0 MEAN RAIN 25.90
 RW CLASS  6 FLOW  30670. % DRAINED 100.00
 RW TEMP 23.80 BOD    2.0 SS  200.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8371 CNAT 0.2570


SEQ NO 232 U.A NO.  71906 UA NAME SIOUX CITY IA             CSO AREA       0. CSO POP        0.
UA POP    87157. UA SIZE   56.0 70 SMSA POP   116189.
2000 SMSA POP   109600. NO.CSO PTS.   2# DAYS W/ RAIN   98.0 MEAN RAIN 24.77
 RW CLASS  4 FLOW  33126. % DRAINED 100.00
 RW TEMP 23.20 BOD    2.5 SS  200.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8371 CNAT 0.2570


SEQ NO 233 U.A NO.  71907 UA NAME WATERLOO IA               CSO AREA       0. CSO POP        0.
UA POP   112881. UA SIZE   69.4 70 SMSA POP   132196.
2000 SMSA POP   142600. NO.CSO PTS.   0# DAYS W/ RAIN   91.0 MEAN RAIN 31.48
 RW CLASS  2 FLOW   2714. % DRAINED 100.00
 RW TEMP 23.20 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.70
 COST FACTOR 0.8371 CNAT 0.2350


SEQ NO 234 U.A NO.  72001 UA NAME KANSAS CITY METRO KS     CSO AREA   22600. CSO POP   259000.
UA POP   350208. UA SIZE   85.9 70 SMSA POP  1273926.
2000 SMSA POP  1793300. NO.CSO PTS.   2# DAYS W/ RAIN   98.0 MEAN RAIN 34.07
 RW CLASS  5 FLOW  54270. % DRAINED 100.00
 RW TEMP 24.90 BOD    1.5 SS  200.0 PB 0.0167 HARD  200.0 ALK  100.0 PH 8.00
 COST FACTOR 1.0000 CNAT 0.2570


SEQ NO 235 U.A NO.  72002 UA NAME ST JOSEPH METRO KS       CSO AREA       0. CSO POP        0.
UA POP     1283. UA SIZE    1.2 70 SMSA POP    98828.
2000 SMSA POP    83900. NO.CSO PTS.   0# DAYS W/ RAIN   95.0 MEAN RAIN 34.18
 RW CLASS  5 FLOW  38910. % DRAINED 100.00
 RW TEMP 24.90 BOD    1.5 SS  200.0 PB 0.0167 HARD  200.0 ALK  100.0 PH 8.00
 COST FACTOR 1.0000 CNAT 0.2570
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SEQ NO 236 U.A NO.  72003 UA NAME TOPEKA KS
UA POP   132108. UA SIZE   52.8 70 SMSA POP   180169.           CSC AREA    5500. CSO POP   120000.
2000 SMSA POP   214100. NO.CSO PTS.  12# DAYS W/ RAIN   95.0 MEAN RAIN 33.28
 RW CLASS  4 FLOW   5407. % DRAINED 100.00
 RW TEMP 24.90 BOD    1.0 SS  240.0 PB 0.0167 HARD  100.0 ALK   90.0 PH 7.80
 COST FACTOR 1.0000 CMAT 0.2570


SEQ NO 237 U.A NO.  72004 UA NAME WICHITA KS
UA POP   302334. UA SIZE  105.1 70 SMSA POP   389352.           CSC AREA       0. CSO POP        0.
2000 SMSA POP   369000. NO.CSO PTS.   0# DAYS W/ RAIN   76.0 MEAN RAIN 30.70
 RW CLASS  4 FLOW   1092. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS  300.0 PB 0.0167 HARD   45.0 ALK   55.0 PH 7.50
 COST FACTOR 1.0000 CMAT 0.0820


SEQ NO  96 U.A NO.  42101 UA NAME CINCINNATI METRO KY       CSC AREA       0. CSO POP        0.
UA POP   196978. UA SIZE   59.9 70 SMSA POP  1387207.
2000 SMSA POP  1738000. NO.CSO PTS.   0# DAYS W/ RAIN  134.0 MEAN RAIN 39.34
 RW CLASS  5 FLOW 113600. % DRAINED 100.00
 RW TEMP 23.80 BOD    2.0 SS   80.0 PB 0.0167 HARD  130.0 ALK   50.0 PH 7.90
 COST FACTOR 1.0415 CMAT 0.3860


SEQ NO  97 U.A NO.  42102 UA NAME HUNTINGTON METRO KY       CSC AREA       0. CSO POP        0.
UA POP    53316. UA SIZE   22.6 70 SMSA POP   286935.
2000 SMSA POP   262700. NO.CSO PTS.   0# DAYS W/ RAIN  136.0 MEAN RAIN 41.79
 RW CLASS  5 FLOW 174180. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   60.0 ALK   10.0 PH 7.30
 COST FACTOR 1.0415 CMAT 0.3860


SEQ NO  98 U.A NO.  42103 UA NAME LEXINGTON KY
UA POP   159538. UA SIZE   39.9 70 SMSA POP   266701.           CSC AREA       0. CSO POP        0.
2000 SMSA POP   300500. NO.CSO PTS.   0# DAYS W/ RAIN  133.0 MEAN RAIN 43.71
 RW CLASS  2 FLOW     32. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.5 SS   80.0 PB 0.0167 HARD  125.0 ALK   50.0 PH 7.90
 COST FACTOR 1.0415 CMAT 0.3860


SEQ NO  99 U.A NO.  42104 UA NAME LOUISVILLE KY
UA POP   657908. UA SIZE  183.8 70 SMSA POP   867330.           CSC AREA   28800. CSO POP   457450.
2000 SMSA POP  1297100. NO.CSO PTS.  13# DAYS W/ RAIN  122.0 MEAN RAIN 41.47
 RW CLASS  5 FLOW 113600. % DRAINED 100.00
 RW TEMP 25.40 BOD    3.0 SS   80.0 PB 0.0167 HARD  150.0 ALK  100.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.3860
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SEQ NO 100 U.A NO.  42105 UA NAME OWENSBORO KY                CSC AREA    5098. CSO POP    33600.
UA POP    53133. UA SIZE   11.9 70 SMSA POP    79486.
2000 SMSA POP   112300. NO.CSO PTS.   3# DAYS W/ RAIN  115.0 MEAN RAIN 44.29
 RW CLASS  5 FLOW 113600. % DRAINED 100.00
 RW TEMP 26.70 BOD    3.0 SS   80.0 PB 0.0167 HARD  175.0 ALK  125.0 PH 8.00
 COST FACTOR 1.1009 CMAT 0.3860


SEQ NO 302 U.A NO.  42106 UA NAME CLARKSVILLE METRO KY        CSC AREA       0. CSO POP        0.
UA POP    13616. UA SIZE    6.2 70 SMSA POP   118945.
2000 SMSA POP   260000. NO.CSO PTS.   0# DAYS W/ RAIN  120.0 MEAN RAIN 47.46
 RW CLASS  4 FLOW  19000. % DRAINED 100.00
 RW TEMP 26.00 BOD    2.5 SS   72.0 PB 0.0117 HARD  100.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.4130


SEQ NO 189 U.A NO.  62201 UA NAME BATON ROUGE LA              CSC AREA       0. CSO POP        0.
UA POP   249463. UA SIZE   84.6 70 SMSA POP   375628.
2000 SMSA POP   402900. NO.CSO PTS.   0# DAYS W/ RAIN  106.0 MEAN RAIN 59.13
 RW CLASS  5 FLOW 582500. % DRAINED 100.00
 RW TEMP 27.80 BOD    1.0 SS   28.0 PB 0.0067 HARD   10.0 ALK   20.0 PH 6.70
 COST FACTOR 0.9256 CMAT 0.3270


SEQ NO 190 U.A NO.  62202 UA NAME LAFAYETTE LA                CSC AREA       0. CSO POP        0.
UA POP    78544. UA SIZE   24.9 70 SMSA POP   111643.
2000 SMSA POP   105400. NO.CSO PTS.   0# DAYS W/ RAIN  107.0 MEAN RAIN 59.13
 RW CLASS  6 FLOW      0. % DRAINED 100.00
 RW TEMP 27.80 BOD    1.0 SS   28.0 PB 0.0067 HARD   10.0 ALK   20.0 PH 6.70
 COST FACTOR 0.9256 CMAT 0.3270


SEQ NO 191 U.A NO.  62203 UA NAME LAKE CHARLES LA             CSC AREA       0. CSO POP        0.
UA POP    88260. UA SIZE   33.5 70 SMSA POP   145415.
2000 SMSA POP   156800. NO.CSO PTS.   0# DAYS W/ RAIN  107.0 MEAN RAIN 57.82
 RW CLASS  3 FLOW      0. % DRAINED 100.00
 RW TEMP 28.80 BOD    1.0 SS   32.0 PB 0.0117 HARD   18.0 ALK   25.0 PH 7.00
 COST FACTOR 0.9256 CMAT 0.1480


SEQ NO 192 U.A NO.  62204 UA NAME MONROE LA                   CSC AREA       0. CSO POP        0.
UA POP    90567. UA SIZE   40.1 70 SMSA POP   115387.
2000 SMSA POP   146100. NO.CSO PTS.   0# DAYS W/ RAIN   90.0 MEAN RAIN 51.29
 RW CLASS  4 FLOW  18220. % DRAINED 100.00
 RW TEMP 28.20 BOD    1.0 SS   48.0 PB 0.0067 HARD   15.0 ALK   50.0 PH 7.00
 COST FACTOR 0.7934 CMAT 0.3300
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SEQ NO 193 U.A NO.  62205 UA NAME NEW ORLEANS LA           CSC AREA      0. CSO POP        0.
UA POP   961728. UA SIZE   84.0 70 SMSA POP  1046470.
2000 SMSA POP  1221700. NO.CSO PTS.   0# DAYS W/ RAIN  120.0 MEAN RAIN 63.54
 RW CLASS  5 FLOW 582500. % DRAINED  50.00
 RW TEMP 28.80 BOD    1.0 SS   28.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.9256 CHAT 0.3270


SEQ NO 194 U.A NO.  62206 UA NAME SHREVEPORT LA            CSC AREA      0. CSO POP        0.
UA POP   234564. UA SIZE   94.3 70 SMSA POP   333826.
2000 SMSA POP   355000. NO.CSO PTS.   0# DAYS W/ RAIN   90.0 MEAN RAIN 45.10
 RW CLASS  4 FLOW  24690. % DRAINED 100.00
 RW TEMP 28.20 BOD    1.0 SS   60.0 PB 0.0117 HARD   18.0 ALK   50.0 PH 7.40
 COST FACTOR 0.7934 CHAT 0.3300


SEQ NO 304 U.A NO.  62207 UA NAME ALEXANDRIA LA            CSC AREA      0. CSO POP        0.
UA POP    77609. UA SIZE   37.1 70 SMSA POP   131749.
2000 SMSA POP   138000. NO.CSO PTS.   0# DAYS W/ RAIN  106.0 MEAN RAIN 63.28
 RW CLASS  4 FLOW  31870. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   40.0 PB 0.0067 HARD   15.0 ALK   35.0 PH 7.00
 COST FACTOR 0.9256 CHAT 0.3300


SEQ NO  12 U.A NO.  12301 UA NAME LEWISTON-AUBURN ME       CSC AREA   4500. CSO POP    51300.
UA POP    65212. UA SIZE   67.9 70 SMSA POP    91297.
2000 SMSA POP    89300. NO.CSO PTS.  31# DAYS W/ RAIN  125.0 MEAN RAIN 43.58
 RW CLASS  4 FLOW   6135. % DRAINED 100.00
 RW TEMP 20.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.30
 COST FACTOR 1.2226 CHAT 0.5650


SEQ NO  13 U.A NO.  12302 UA NAME PORTLAND ME              CSC AREA   9678. CSO POP    85200.
UA POP   106599. UA SIZE   55.7 70 SMSA POP   192528.
2000 SMSA POP   225000. NO.CSO PTS.  67# DAYS W/ RAIN  125.0 MEAN RAIN 42.85
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 20.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.30
 COST FACTOR 1.2226 CHAT 0.5650


SEQ NO  46 U.A NO.  32401 UA NAME BALTIMORE MD             CSC AREA      0. CSO POP        0.
UA POP  1579780. UA SIZE  309.6 70 SMSA POP  2071016.
2000 SMSA POP  2488000. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 44.21
 RW CLASS 11 FLOW      0. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 1.0083 CHAT 0.3910
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SEQ NO  47 U.A NO.  32402 UA NAME WASHINGTON DC MTR MD     CSC AREA       0. CSO POP        0.
UA POP  1009138. UA SIZE  248.0 70 SMSA POP  2910111.
2000 SMSA POP  5189600. NO.CSO PTS.   0# DAYS W/ RAIN  111.0 MEAN RAIN 40.78
 RW CLASS 12 FLOW  11190. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 1.0083 CNAT 0.3910


SEQ NO  14 U.A NO.  12501 UA NAME BOSTON MA                 CSC AREA   28000. CSO POP  1005200.
UA POP  2652574. UA SIZE  664.4 70 SMSA POP  3848593.
2000 SMSA POP  4995500. NO.CSO PTS. 100# DAYS W/ RAIN  128.0 MEAN RAIN 42.77
 RW CLASS 11 FLOW    371. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1349 CNAT 0.5650


SEQ NO  15 U.A NO.  12502 UA NAME BROCKTON MA               CSC AREA       0. CSO POP        0.
UA POP   148844. UA SIZE   52.5 70 SMSA POP  3848593.
2000 SMSA POP  4995500. NO.CSO PTS.   0# DAYS W/ RAIN  135.0 MEAN RAIN 40.96
 RW CLASS  1 FLOW      0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1349 CNAT 0.5650


SEQ NO  16 U.A NO.  12503 UA NAME FALL RIVER MA             CSC AREA    3840. CSO POP    92600.
UA POP   123491. UA SIZE   30.5 70 SMSA POP   444301.
2000 SMSA POP   494700. NO.CSO PTS.  19# DAYS W/ RAIN  123.0 MEAN RAIN 45.28
 RW CLASS 11 FLOW      0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1349 CNAT 0.5650


SEQ NO  17 U.A NO.  12504 UA NAME FITCHBURG MA              CSC AREA    1182. CSO POP    41800.
UA POP    78053. UA SIZE   60.9 70 SMSA POP   637037.
2000 SMSA POP   814600. NO.CSO PTS.   0# DAYS W/ RAIN  129.0 MEAN RAIN 45.74
 RW CLASS  3 FLOW    127. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CNAT 0.5650


SEQ NO  18 U.A NO.  12505 UA NAME LAWRENCE MA               CSC AREA    9000. CSO POP   123900.
UA POP   182438. UA SIZE   72.0 70 SMSA POP  3848593.
2000 SMSA POP  4995500. NO.CSO PTS.  18# DAYS W/ RAIN  128.0 MEAN RAIN 40.96
 RW CLASS  4 FLOW   7432. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1349 CNAT 0.5650
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SEQ NO  19 U.A NO.  12506 UA NAME LOWELL MA                    CSO AREA       0. CSO POP        0.
UA POP   182731. UA SIZE   62.1 70 SMSA POP  3848593.
2000 SMSA POP  4995500. NO.CSO PTS.   0# DAYS W/ RAIN  128.0 MEAN RAIN 43.34
 RW CLASS  2 FLOW    613. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1055 CMAT 0.5650


SEQ NO  20 U.A NO.  12507 UA NAME NEW BEDFORD MA               CSO AREA       0. CSO POP        0.
UA POP   133667. UA SIZE   33.7 70 SMSA POP   444301.
2000 SMSA POP   494700. NO.CSO PTS.   0# DAYS W/ RAIN  123.0 MEAN RAIN 41.05
 RW CLASS 11 FLOW      0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1349 CMAT 0.5650


SEQ NO  21 U.A NO.  12508 UA NAME PITTSFIELD MA                CSO AREA       0. CSO POP        0.
UA POP    62872. UA SIZE   43.6 70 SMSA POP   149402.
2000 SMSA POP   194300. NO.CSO PTS.   0# DAYS W/ RAIN  152.0 MEAN RAIN 44.42
 RW CLASS  3 FLOW    114. % DRAINED  50.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO  22 U.A NO.  12509 UA NAME PROVIDENCE METRO MA          CSO AREA       0. CSO POP        0.
UA POP    65574. UA SIZE   43.9 70 SMSA POP   855495.
2000 SMSA POP   945500. NO.CSO PTS.   0# DAYS W/ RAIN  123.0 MEAN RAIN 39.63
 RW CLASS  4 FLOW     40. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1209 CMAT 0.5650


SEQ NO  23 U.A NO.  12510 UA NAME SPRINGFIELD MA               CSO AREA   15037. CSO POP   277309.
UA POP   456135. UA SIZE  211.1 70 SMSA POP   583031.
2000 SMSA POP   667400. NO.CSO PTS.  84# DAYS W/ RAIN  128.0 MEAN RAIN 45.11
 RW CLASS  4 FLOW  16230. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0919 CMAT 0.5650


SEQ NO  24 U.A NO.  12511 UA NAME WORCESTER MA                 CSO AREA    3240. CSO POP   182000.
UA POP   247416. UA SIZE   84.4 70 SMSA POP   637037.
2000 SMSA POP   814600. NO.CSO PTS.  23# DAYS W/ RAIN  129.0 MEAN RAIN 45.41
 RW CLASS  3 FLOW     53. % DRAINED  50.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1055 CMAT 0.5650
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SEQ NO 143 U.A NO.  52601 UA NAME ANN ARBOR MI              CSO AREA       0. CSO POP        0.
UA POP   178605. UA SIZE   45.0 70 SMSA POP   243103.
2000 SMSA POP   363000. NO.CSO PTS.   0# DAYS W/ RAIN  130.0 MEAN RAIN 30.67
 RW CLASS  4 FLOW    452. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   80.0 ALK   90.0 PH 7.50
 COST FACTOR 1.0415 CRAT 0.4970


SEQ NO 144 U.A NO.  52602 UA NAME BAY CITY MI               CSO AREA    2880. CSO POP    25000.
UA POP    78097. UA SIZE   26.2 70 SMSA POP   117339.
2000 SMSA POP   142000. NO.CSO PTS.  30# DAYS W/ RAIN  129.0 MEAN RAIN 26.73
 RW CLASS  3 FLOW  18457. % DRAINED 100.00
 RW TEMP 20.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   70.0 ALK   75.0 PH 7.20
 COST FACTOR 1.0577 CRAT 0.3500


SEQ NO 145 U.A NO.  52603 UA NAME DETROIT MI                CSO AREA  195581. CSO POP  1916990.
UA POP  3970583. UA SIZE  872.0 70 SMSA POP  4435051.
2000 SMSA POP  5322600. NO.CSO PTS. 220# DAYS W/ RAIN  130.0 MEAN RAIN 30.95
 RW CLASS  4 FLOW 190800. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   70.0 ALK   60.0 PH 7.20
 COST FACTOR 1.0415 CRAT 0.4970


SEQ NO 146 U.A NO.  52604 UA NAME FLINT MI                  CSO AREA    1035. CSO POP    12400.
UA POP   330128. UA SIZE   96.4 70 SMSA POP   508664.
2000 SMSA POP   767000. NO.CSO PTS.   1# DAYS W/ RAIN  129.0 MEAN RAIN 30.14
 RW CLASS  3 FLOW   1131. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   70.0 ALK   60.0 PH 7.20
 COST FACTOR 1.0415 CRAT 0.3500


SEQ NO 147 U.A NO.  52605 UA NAME GRAND RAPIDS MI           CSO AREA    4968. CSO POP    66960.
UA POP   352703. UA SIZE  146.2 70 SMSA POP   539225.
2000 SMSA POP   653800. NO.CSO PTS.  14# DAYS W/ RAIN  137.0 MEAN RAIN 31.19
 RW CLASS  3 FLOW   5694. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.5 SS   20.0 PB 0.0167 HARD   80.0 ALK  100.0 PH 7.30
 COST FACTOR 1.0577 CRAT 0.3500


SEQ NO 148 U.A NO.  52606 UA NAME JACKSON MI                CSO AREA       0. CSO POP        0.
UA POP    78572. UA SIZE   36.1 70 SMSA POP   143274.
2000 SMSA POP   187400. NO.CSO PTS.   0# DAYS W/ RAIN  137.0 MEAN RAIN 31.15
 RW CLASS  3 FLOW    120. % DRAINED  90.00
 RW TEMP 22.10 BOD    1.5 SS   20.0 PB 0.0167 HARD   90.0 ALK    0.0 PH 7.50
 COST FACTOR 1.0415 CRAT 0.3500
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SEQ NO 149 U.A NO.  52607 UA NAME KALAMAZOO MI             CSO AREA      0. CSO POP       0.
UA POP   152083. UA SIZE   73.3 70 SMSA POP   257723.
2000 SMSA POP   293700. NO.CSO PTS.   0# DAYS W/ RAIN  137.0 MEAN RAIN 34.48
 RW CLASS  1 FLOW     56. % DRAINED 100.00
 RW TEMP 20.40 BOD    1.5 SS   40.0 PB 0.0167 HARD   90.0 ALK  120.0 PH 7.50
 COST FACTOR 1.0577 CRAT 0.3500


SEQ NO 150 U.A NO.  52608 UA NAME LANSING MI               CSO AREA   8840. CSO POP   85000.
UA POP   229518. UA SIZE   73.4 70 SMSA POP   424271.
2000 SMSA POP   562100. NO.CSO PTS.  49# DAYS W/ RAIN  137.0 MEAN RAIN 31.18
 RW CLASS  3 FLOW   8371. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   70.0 ALK   75.0 PH 7.40
 COST FACTOR 1.0577 CRAT 0.3500


SEQ NO 151 U.A NO.  52609 UA NAME MUSKEGON MI              CSO AREA   7032. CSO POP   50112.
UA POP   105716. UA SIZE   52.3 70 SMSA POP   175410.
2000 SMSA POP   180400. NO.CSO PTS.   0# DAYS W/ RAIN  140.0 MEAN RAIN 30.07
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.5 SS   20.0 PB 0.0167 HARD   80.0 ALK  100.0 PH 7.30
 COST FACTOR 1.0577 CRAT 0.3500


SEQ NO 152 U.A NO.  52610 UA NAME SAGINAW MI               CSO AREA  12790. CSO POP   95500.
UA POP   147552. UA SIZE   43.5 70 SMSA POP   219743.
2000 SMSA POP   283200. NO.CSO PTS.  35# DAYS W/ RAIN  129.0 MEAN RAIN 28.04
 RW CLASS  3 FLOW   2588. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   70.0 ALK   60.0 PH 7.20
 COST FACTOR 1.0415 CRAT 0.3500


SEQ NO 153 U.A NO.  52611 UA NAME SOUTH BEND METRO MI      CSO AREA   1830. CSO POP   11100.
UA POP    23424. UA SIZE   13.6 70 SMSA POP   280031.
2000 SMSA POP   327900. NO.CSO PTS.  20# DAYS W/ RAIN  136.0 MEAN RAIN 35.59
 RW CLASS  4 FLOW  29140. % DRAINED 100.00
 RW TEMP 22.10 BOD    2.0 SS   88.0 PB 0.0167 HARD  200.0 ALK  140.0 PH 8.00
 COST FACTOR 1.0415 CRAT 0.3500


SEQ NO 154 U.A NO.  52612 UA NAME TOLEDO METRO MI          CSO AREA    930. CSO POP    2712.
UA POP    11861. UA SIZE    6.9 70 SMSA POP   762658.
2000 SMSA POP   900100. NO.CSO PTS.   0# DAYS W/ RAIN  131.0 MEAN RAIN 31.84
 RW CLASS  3 FLOW    842. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   80.0 ALK   90.0 PH 7.50
 COST FACTOR 1.0415 CRAT 0.4970
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SEQ NO 308 U.A NO.  52613 UA NAME BATTLE CREEK MI              CSC AREA       0. CSO POP        0.
UA POP    77922. UA SIZE   31.1 70 SMSA POP   180129.
2000 SMSA POP   187400. NO.CSO PTS.   0# DAYS W/ RAIN  137.0 MEAN RAIN 33.09
 RW CLASS  2 FLOW     650. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.5 SS   40.0 PB 0.0167 HARD   95.0 ALK  100.0 PH 7.50
 COST FACTOR 1.0577 CMAT 0.3500


SEQ NO 155 U.A NO.  52701 UA NAME DULUTH MN                    CSC AREA    2597. CSO POP    31360.
UA POP   105639. UA SIZE   71.1 70 SMSA POP   265350.
2000 SMSA POP   249300. NO.CSO PTS.   0# DAYS W/ RAIN  135.0 MEAN RAIN 28.97
 RW CLASS  8 FLOW       0. % DRAINED 100.00
 RW TEMP 19.30 BOD    2.5 SS   40.0 PB 0.0167 HARD  100.0 ALK   90.0 PH 7.50
 COST FACTOR 1.2468 CMAT 0.0720


SEQ NO 156 U.A NO.  52702 UA NAME FARGO METRO MN               CSC AREA       0. CSO POP        0.
UA POP    32026. UA SIZE    8.8 70 SMSA POP   120261.
2000 SMSA POP   128000. NO.CSO PTS.   0# DAYS W/ RAIN  106.0 MEAN RAIN 18.73
 RW CLASS  5 FLOW     547. % DRAINED 100.00
 RW TEMP 19.90 BOD    3.0 SS  180.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.0720


SEQ NO 157 U.A NO.  52703 UA NAME LACROSSE METRO MN            CSC AREA       0. CSO POP        0.
UA POP     3142. UA SIZE    2.3 70 SMSA POP    80468.
2000 SMSA POP   100000. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 28.92
 RW CLASS  4 FLOW  25890. % DRAINED 100.00
 RW TEMP 22.10 BOD    3.0 SS  100.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.2350


SEQ NO 158 U.A NO.  52704 UA NAME MINNEAPOLIS MN               CSC AREA   22437. CSO POP   204913.
UA POP  1704422. UA SIZE  721.4 70 SMSA POP  1965391.
2000 SMSA POP  2760000. NO.CSO PTS.  87# DAYS W/ RAIN  113.0 MEAN RAIN 24.78
 RW CLASS  4 FLOW  10530. % DRAINED 100.00
 RW TEMP 21.60 BOD    3.0 SS   80.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.2350


SEQ NO 159 U.A NO.  52705 UA NAME ROCHESTER MN                 CSC AREA       0. CSO POP        0.
UA POP    56604. UA SIZE   15.2 70 SMSA POP   961516.
2000 SMSA POP   137100. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 28.46
 RW CLASS  3 FLOW     150. % DRAINED 100.00
 RW TEMP 22.10 BOD    3.0 SS  100.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.2350
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SEQ NO 316 U.A NO.  52706 UA NAME ST CLOUD MN              CSO AREA     365. CSO POP     4000.
UA POP    52059. UA SIZE   18.8 70 SMSA POP   134585.
2000 SMSA POP   185000. NO.CSO PTS.   5# DAYS W/ RAIN  108.0 MEAN RAIN 25.92
 RW CLASS  4 FLOW  17000. % DRAINED 100.00
 RW TEMP 20.40 BOD    3.0 SS   80.0 PB 0.0167 HARD  150.0 ALK  150.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.2350


SEQ NO 101 U.A NO.  42801 UA NAME BILOXI GULFPORT MS       CSO AREA       0. CSO POP        0.
UA POP   121601. UA SIZE   63.7 70 SMSA POP   160070.
2000 SMSA POP   146100. NO.CSO PTS.   0# DAYS W/ RAIN  123.0 MEAN RAIN 57.59
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 26.70 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   10.0 PH 6.40
 COST FACTOR 1.1009 CMAT 0.3270


SEQ NO 102 U.A NO.  42802 UA NAME JACKSON MS               CSO AREA       0. CSO POP        0.
UA POP   190060. UA SIZE   72.2 70 SMSA POP   258906.
2000 SMSA POP   386300. NO.CSO PTS.   0# DAYS W/ RAIN  107.0 MEAN RAIN 50.86
 RW CLASS  4 FLOW   3937. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   20.0 PB 0.0067 HARD   10.0 ALK   15.0 PH 7.00
 COST FACTOR 1.1009 CMAT 0.3270


SEQ NO 103 U.A NO.  42803 UA NAME MEMPHIS METRO MS         CSO AREA       0. CSO POP        0.
UA POP     8931. UA SIZE    3.2 70 SMSA POP   834103.
2000 SMSA POP  1112700. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 46.81
 RW CLASS  4 FLOW 470800. % DRAINED 100.00
 RW TEMP 26.70 BOD    1.0 SS   20.0 PB 0.0067 HARD   50.0 ALK  100.0 PH 7.40
 COST FACTOR 1.1009 CMAT 0.3270


SEQ NO 238 U.A NO.  72901 UA NAME COLUMBIA MO              CSO AREA       0. CSO POP        0.
UA POP    59231. UA SIZE   42.0 70 SMSA POP    80935.
2000 SMSA POP   175500. NO.CSO PTS.   0# DAYS W/ RAIN  107.0 MEAN RAIN 36.96
 RW CLASS  1 FLOW     60. % DRAINED  75.00
 RW TEMP 24.90 BOD    2.0 SS  160.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.1009 CMAT 0.2570


SEQ NO 239 U.A NO.  72902 UA NAME KANSAS CITY MO           CSO AREA   36480. CSO POP   292000.
UA POP   751579. UA SIZE  407.3 70 SMSA POP  1273926.
2000 SMSA POP  1793300. NO.CSO PTS.  10# DAYS W/ RAIN   98.0 MEAN RAIN 34.07
 RW CLASS  3 FLOW     20. % DRAINED 100.00
 RW TEMP 24.90 BOD    1.5 SS  200.0 PB 0.0167 HARD  200.0 ALK  100.0 PH 8.00
 COST FACTOR 1.0000 CMAT 0.2570
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                URBANIZED AREA DATA BASE LISTING


                                                  CSO AREA       0. CSO POP         0.
SEQ NO 240 U.A NO.  72903 UA NAME SPRINGFIELD MO
UA POP    121340. UA SIZE   63.1 70 SMSA POP   168053.
2000 SMSA POP   222000. NO.CSO PTS.   0# DAYS W/ RAIN  106.0 MEAN RAIN 41.08
 RW CLASS  4 FLOW     215. % DRAINED  60.00
 RW TEMP 25.40 BOD    1.0 SS  200.0 PB 0.0167 HARD   75.0 ALK  100.0 PH 8.00
 COST FACTOR 1.0000 CWAT 0.3300


                                                  CSO AREA    5000. CSO POP    44800.
SEQ NO 241 U.A NO.  72904 UA NAME ST JOSEPH MO
UA POP    77223. UA SIZE   31.9 70 SMSA POP    98828.
2000 SMSA POP    83900. NO.CSO PTS.   1# DAYS W/ RAIN   95.0 MEAN RAIN 34.18
 RW CLASS  5 FLOW  38510. % DRAINED 100.00
 RW TEMP 24.90 BOD    1.5 SS  200.0 PB 0.0167 HARD  200.0 ALK  100.0 PH 8.00
 COST FACTOR 1.0000 CWAT 0.3270


                                                  CSO AREA   45790. CSO POP   793000.
SEQ NO 242 U.A NO.  72905 UA NAME ST LOUIS MO
UA POP  1568467. UA SIZE  349.9 70 SMSA POP  2410602.
2000 SMSA POP  2825200. NO.CSO PTS.  60# DAYS W/ RAIN  104.0 MEAN RAIN 36.46
 RW CLASS  6 FLOW 174500. % DRAINED 100.00
 RW TEMP 25.40 BOD    3.0 SS  140.0 PB 0.0167 HARD  200.0 ALK  190.0 PH 8.00
 COST FACTOR 1.1009 CWAT 0.3270


                                                  CSO AREA       0. CSO POP         0.
SEQ NO 250 U.A NO.  83001 UA NAME BILLINGS MT
UA POP    71197. UA SIZE   26.9 70 SMSA POP    87367.
2000 SMSA POP   102000. NO.CSO PTS.   0# DAYS W/ RAIN   93.0 MEAN RAIN 13.23
 RW CLASS  2 FLOW  10653. % DRAINED 100.00
 RW TEMP 18.20 BOD    1.5 SS  400.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8843 CWAT 0.0720


                                                  CSO AREA       0. CSO POP         0.
SEQ NO 251 U.A NO.  83002 UA NAME GREAT FALLS MT
UA POP    70905. UA SIZE   21.8 70 SMSA POP    81804.
2000 SMSA POP    81500. NO.CSO PTS.   0# DAYS W/ RAIN   99.0 MEAN RAIN 14.07
 RW CLASS  5 FLOW   8040. % DRAINED 100.00
 RW TEMP 18.20 BOD    2.0 SS   12.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.50
 COST FACTOR 0.8843 CWAT 0.0720


                                                  CSO AREA       0. CSO POP         0.
SEQ NO 243 U.A NO.  73101 UA NAME LINCOLN NE
UA POP   153443. UA SIZE   52.1 70 SMSA POP   167972.
2000 SMSA POP   220700. NO.CSO PTS.   0# DAYS W/ RAIN   93.0 MEAN RAIN 25.73
 RW CLASS  1 FLOW     198. % DRAINED 100.00
 RW TEMP 24.90 BOD    1.5 SS  240.0 PB 0.0167 HARD  200.0 ALK  100.0 PH 7.80
 COST FACTOR 0.8371 CWAT 0.0720
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SEQ NO 244 U.A NO.  73102 UA NAME OMAHA NE                  CSO AREA   25201. CSO POP   191505.
UA POP   426929. UA SIZE  110.2 70 SMSA POP   542646.
2000 SMSA POP   694100. NO.CSO PTS.  22# DAYS W/ RAIN   94.0 MEAN RAIN 25.90
 RW CLASS  6 FLOW  30670. % DRAINED 100.00
 RW TEMP 24.30 BOD    1.8 SS  240.0 PB 0.0167 HARD  200.0 ALK  150.0 PH 7.80
 COST FACTOR 0.8371 CWAT 0.0720


SEQ NO 245 U.A NO.  73103 UA NAME SIOUX CITY METRO NE       CSO AREA       0. CSO POP        0.
UA POP     7920. UA SIZE    3.6 70 SMSA POP   116189.
2000 SMSA POP   109600. NO.CSO PTS.   0# DAYS W/ RAIN   98.0 MEAN RAIN 24.77
 RW CLASS  4 FLOW  33126. % DRAINED 100.00
 RW TEMP 23.20 BOD    2.0 SS  240.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8371 CWAT 0.0720


SEQ NO 277 U.A NO.  93201 UA NAME LAS VEGAS NV              CSO AREA       0. CSO POP        0.
UA POP   236681. UA SIZE  121.2 70 SMSA POP   273288.
2000 SMSA POP   481100. NO.CSO PTS.   0# DAYS W/ RAIN   25.0 MEAN RAIN 4.35
 RW CLASS  2 FLOW      1. % DRAINED 100.00
 RW TEMP 29.30 BOD    0.5 SS   20.0 PB 0.0200 HARD  100.0 ALK  100.0 PH 7.50
 COST FACTOR 1.3175 CWAT 0.0850


SEQ NO 278 U.A NO.  93202 UA NAME RENO NV                   CSO AREA       0. CSO POP        0.
UA POP    99687. UA SIZE   37.5 70 SMSA POP   121068.
2000 SMSA POP   236800. NO.CSO PTS.   0# DAYS W/ RAIN   47.0 MEAN RAIN 6.96
 RW CLASS  2 FLOW    671. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.5 SS    8.0 PB 0.0067 HARD   20.0 ALK   20.0 PH 7.50
 COST FACTOR 1.0855 CWAT 0.0880


SEQ NO  25 U.A NO.  13301 UA NAME LAWRENCE METRO NH         CSO AREA       0. CSO POP        0.
UA POP    17842. UA SIZE   12.4 70 SMSA POP  3848593.
2000 SMSA POP  4995500. NO.CSO PTS.   0# DAYS W/ RAIN  128.0 MEAN RAIN 40.96
 RW CLASS  4 FLOW   7432. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1226 CWAT 0.5650


SEQ NO  26 U.A NO.  13302 UA NAME MANCHESTER NH             CSO AREA    5900. CSO POP    84400.
UA POP    95140. UA SIZE   39.1 70 SMSA POP   223941.
2000 SMSA POP   330300. NO.CSO PTS.  40# DAYS W/ RAIN  120.0 MEAN RAIN 43.20
 RW CLASS  4 FLOW   5255. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1226 CWAT 0.5650
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SEQ NO  27 U.A NO.  13303 UA NAME NASHUA NH                 CSC AREA    3163. CSO POP    54400.
UA POP    60961. UA SIZE   33.5 70 SMSA POP   223941.
2000 SMSA POP   330300. NO.CSO PTS.   9# DAYS W/ RAIN  120.0 MEAN RAIN 42.13
 RW CLASS  4 FLOW   5255. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1226 CMAT 0.5650


SEQ NO  30 U.A NO.  23401 UA NAME ALLENTOWN METRO NJ        CSC AREA       0. CSO POP        0.
UA POP    25201. UA SIZE    6.9 70 SMSA POP   594382.
2000 SMSA POP   624300. NO.CSO PTS.   0# DAYS W/ RAIN  122.0 MEAN RAIN 44.12
 RW CLASS  2 FLOW     96. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1985 CMAT 0.4620


SEQ NO  31 U.A NO.  23402 UA NAME ATLANTIC CITY NJ          CSC AREA       0. CSO POP        0.
UA POP   134016. UA SIZE   67.1 70 SMSA POP   175043.
2000 SMSA POP   207400. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 43.78
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1818 CMAT 0.4620


SEQ NO  32 U.A NO.  23403 UA NAME NEW YORK CITY MTR NJ      CSC AREA   53747. CSO POP  1222129.
UA POP  4837261. UA SIZE 2045.0 70 SMSA POP  9973716.
2000 SMSA POP 14323200. NO.CSO PTS. 214# DAYS W/ RAIN  119.0 MEAN RAIN 42.38
 RW CLASS 13 FLOW     40. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.4322 CMAT 0.4620


SEQ NO  33 U.A NO.  23404 UA NAME PHILADELPHIA MTR NJ       CSC AREA    7867. CSO POP   151730.
UA POP   744045. UA SIZE   49.1 70 SMSA POP  4824110.
2000 SMSA POP  6015800. NO.CSO PTS.  56# DAYS W/ RAIN  115.0 MEAN RAIN 42.48
 RW CLASS 13 FLOW  11430. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1818 CMAT 0.4620


SEQ NO  34 U.A NO.  23405 UA NAME TRENTON NJ                CSC AREA     684. CSO POP     1860.
UA POP   242673. UA SIZE   54.8 70 SMSA POP   304116.
2000 SMSA POP   459400. NO.CSO PTS.   3# DAYS W/ RAIN  121.0 MEAN RAIN 41.28
 RW CLASS  2 FLOW  11660. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1205 CMAT 0.4620
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SEQ NO  35 U.A NO.  23406 UA NAME VINELAND NJ                 CSO AREA       0. CSO POP        0.
UA POP    73579. UA SIZE   85.3 70 SMSA POP   121374.
2000 SMSA POP   179800. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 43.74
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1818 CRAT 0.4620


SEQ NO  36 U.A NO.  23407 UA NAME WILMINGTON METRO NJ         CSO AREA       0. CSO POP        0.
UA POP    21593. UA SIZE   12.7 70 SMSA POP   499493.
2000 SMSA POP   712200. NO.CSO PTS.   0# DAYS W/ RAIN  127.0 MEAN RAIN 44.36
 RW CLASS  1 FLOW    465. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1818 CRAT 0.4620


SEQ NO 195 U.A NO.  63501 UA NAME ALBUQUERQUE NM              CSO AREA       0. CSO POP        0.
UA POP   297451. UA SIZE  114.4 70 SMSA POP   333266.
2000 SMSA POP   461600. NO.CSO PTS.   0# DAYS W/ RAIN   58.0 MEAN RAIN  8.13
 RW CLASS  3 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   60.0 PB 0.0025 HARD   48.0 ALK   90.0 PH 7.50
 COST FACTOR 0.8843 CRAT 0.1480


SEQ NO  37 U.A NO.  23601 UA NAME ALBANY NY                   CSO AREA   15028. CSO POP   233661.
UA POP   486525. UA SIZE  150.5 70 SMSA POP   777977.
2000 SMSA POP   941000. NO.CSO PTS. 116# DAYS W/ RAIN  133.0 MEAN RAIN 37.95
 RW CLASS 13 FLOW 132900. % DRAINED  80.00
 RW TEMP 19.90 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 1.1985 CRAT 0.4620


SEQ NO  38 U.A NO.  23602 UA NAME BINGHAMTON NY               CSO AREA    7139. CSO POP   134283.
UA POP   167224. UA SIZE   52.3 70 SMSA POP   302672.
2000 SMSA POP   340100. NO.CSO PTS.  33# DAYS W/ RAIN  133.0 MEAN RAIN 36.24
 RW CLASS  3 FLOW   3608. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.60
 COST FACTOR 1.1722 CRAT 0.3910


SEQ NO  39 U.A NO.  23603 UA NAME BUFFALO NY                  CSO AREA   34166. CSO POP   943488.
UA POP  1086593. UA SIZE  213.7 70 SMSA POP  1349211.
2000 SMSA POP  1419600. NO.CSO PTS. 161# DAYS W/ RAIN  165.0 MEAN RAIN 35.65
 RW CLASS  5 FLOW 204000. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.80
 COST FACTOR 1.2171 CRAT 0.4970
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SEQ NO  40 U.A NO.  23604 UA NAME NEW YORK CITY NY          CSC AREA  112426. CSO POP  6670000.
UA POP 11369574. UA SIZE  380.1 70 SMSA POP  9973716.
2000 SMSA POP 14323200. NO.CSO PTS. 366# DAYS W/ RAIN  119.0 MEAN RAIN 42.37
 RW CLASS 13 FLOW     40. % DRAINED  60.00
 RW TEMP 23.20 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.4322 CNAT 0.4620


SEQ NO  41 U.A NO.  23605 UA NAME ROCHESTER NY              CSC AREA    9190. CSO POP   166500.
UA POP   601361. UA SIZE  145.7 70 SMSA POP   961516.
2000 SMSA POP  1412500. NO.CSO PTS.  38# DAYS W/ RAIN  153.0 MEAN RAIN 31.50
 RW CLASS  3 FLOW   2751. % DRAINED  67.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 6.80
 COST FACTOR 1.2171 CNAT 0.4970


SEQ NO  42 U.A NO.  23606 UA NAME SYRACUSE NY               CSC AREA   13600. CSO POP   317100.
UA POP   376169. UA SIZE   96.2 70 SMSA POP   636596.
2000 SMSA POP   789700. NO.CSO PTS. 123# DAYS W/ RAIN  167.0 MEAN RAIN 37.60
 RW CLASS  8 FLOW      0. % DRAINED  60.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   19.0 ALK   10.0 PH 6.70
 COST FACTOR 1.2000 CNAT 0.4970


SEQ NO  43 U.A NO.  23607 UA NAME UTICA ROME NY             CSC AREA   15360. CSO POP   130930.
UA POP   180355. UA SIZE   74.6 70 SMSA POP   340670.
2000 SMSA POP   355900. NO.CSO PTS.  62# DAYS W/ RAIN  167.0 MEAN RAIN 39.73
 RW CLASS 13 FLOW    397. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.60
 COST FACTOR 1.1902 CNAT 0.4970


SEQ NO 293 U.A NO.  23608 UA NAME POUGHKEEPSIE NY           CSC AREA     700. CSO POP    33270.
UA POP   102649. UA SIZE   54.7 70 SMSA POP   222295.
2000 SMSA POP   352100. NO.CSO PTS.   7# DAYS W/ RAIN  133.0 MEAN RAIN 40.21
 RW CLASS  6 FLOW 132900. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.1985 CNAT 0.4620


SEQ NO 311 U.A NO.  23609 UA NAME ELMIRA NY                 CSC AREA    4828. CSO POP    45300.
UA POP    74039. UA SIZE   23.8 70 SMSA POP   101537.
2000 SMSA POP   116600. NO.CSO PTS.   7# DAYS W/ RAIN  161.0 MEAN RAIN 34.89
 RW CLASS  4 FLOW   2505. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   12.0 ALK   10.0 PH 6.60
 COST FACTOR 1.2171 CNAT 0.3910
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SEQ NO 104 U.A NO.  43701 UA NAME ASHEVILLE NC                  CSC AREA      0. CSO POP        0.
UA POP    72451. UA SIZE   38.2 70 SMSA POP   161059.
2000 SMSA POP   207900. NC.CSO PTS.   0# DAYS W/ RAIN  127.0 MEAN RAIN 37.88
 RW CLASS  4 FLOW   2089. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS   40.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.90
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 105 U.A NO.  43702 UA NAME CHARLOTTE NC                  CSC AREA      0. CSO POP        0.
UA POP   279530. UA SIZE  105.7 70 SMSA POP   557785.
2000 SMSA POP   661300. NC.CSO PTS.   0# DAYS W/ RAIN  110.0 MEAN RAIN 43.38
 RW CLASS  1 FLOW      0. % DRAINED  25.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 106 U.A NO.  43703 UA NAME DURHAM NC                     CSC AREA      0. CSO POP        0.
UA POP   100764. UA SIZE   43.0 70 SMSA POP   419254.
2000 SMSA POP   338400. NC.CSO PTS.   0# DAYS W/ RAIN  113.0 MEAN RAIN 42.65
 RW CLASS  3 FLOW    122. % DRAINED  50.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 107 U.A NO.  43704 UA NAME FAYETVILLE NC                 CSC AREA      0. CSO POP        0.
UA POP   161370. UA SIZE   73.3 70 SMSA POP   212042.
2000 SMSA POP   266200. NC.CSO PTS.   0# DAYS W/ RAIN  113.0 MEAN RAIN 46.44
 RW CLASS  3 FLOW      0. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.60
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 108 U.A NO.  43705 UA NAME GREENSBORO NC                 CSC AREA      0. CSO POP        0.
UA POP   152252. UA SIZE   61.2 70 SMSA POP   724129.
2000 SMSA POP  1016400. NC.CSO PTS.   0# DAYS W/ RAIN  117.0 MEAN RAIN 42.16
 RW CLASS  1 FLOW     53. % DRAINED  40.00
 RW TEMP 23.80 BOD    1.0 SS   40.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.60
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 109 U.A NO.  43706 UA NAME HIGHPOINT NC                  CSC AREA      0. CSO POP        0.
UA POP    93547. UA SIZE   52.1 70 SMSA POP   724129.
2000 SMSA POP  1016400. NC.CSO PTS.   0# DAYS W/ RAIN  117.0 MEAN RAIN 45.69
 RW CLASS  1 FLOW      0. % DRAINED  20.00
 RW TEMP 23.80 BOD    1.0 SS   40.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.60
 COST FACTOR 0.6281 CMAT 0.3060
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                 URBANIZED AREA DATA BASE LISTING


SEQ NO 110 U.A NO.  43707 UA NAME RALEIGH NC                CSO AREA       0. CSO POP          0.
UA POP    152289. UA SIZE   70.5 70 SMSA POP   419254.
2000 SMSA POP   368600. NO.CSO PTS.   0# DAYS W/ RAIN  113.0 MEAN RAIN 46.28
 RW CLASS  2 FLOW      0. % DRAINED  90.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 111 U.A NO.  43708 UA NAME WILMINGTON NC             CSO AREA   10000. CSO POP      29450.
UA POP     57645. UA SIZE   29.3 70 SMSA POP   107219.
2000 SMSA POP   139700. NO.CSO PTS.   3# DAYS W/ RAIN  115.0 MEAN RAIN 51.29
 RW CLASS 11 FLOW      0. % DRAINED 100.00
 RW TEMP 26.70 BOD    1.0 SS   24.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 112 U.A NO.  43709 UA NAME WINSTON SALEM NC          CSO AREA       0. CSO POP          0.
UA POP   142584. UA SIZE   66.0 70 SMSA POP   724129.
2000 SMSA POP  1016400. NO.CSO PTS.   0# DAYS W/ RAIN  117.0 MEAN RAIN 45.69
 RW CLASS  1 FLOW     73. % DRAINED  70.00
 RW TEMP 23.80 BOD    1.0 SS   40.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.60
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 291 U.A NO.  43710 UA NAME GASTONIA NC               CSO AREA       0. CSO POP          0.
UA POP    94725. UA SIZE   58.5 70 SMSA POP   557785.
2000 SMSA POP   187700. NO.CSO PTS.   0# DAYS W/ RAIN  110.0 MEAN RAIN 47.38
 RW CLASS  2 FLOW      0. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 309 U.A NO.  43711 UA NAME BURLINGTON NC             CSO AREA       0. CSO POP          0.
UA POP    59891. UA SIZE   30.7 70 SMSA POP    96502.
2000 SMSA POP   152000. NO.CSO PTS.   0# DAYS W/ RAIN  117.0 MEAN RAIN 44.95
 RW CLASS  2 FLOW      0. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 0.6281 CMAT 0.3060


SEQ NO 252 U.A NO.  83801 UA NAME FARGO ND                  CSO AREA     965. CSO POP       9650.
UA POP    53420. UA SIZE   15.3 70 SMSA POP   120261.
2000 SMSA POP   128000. NO.CSO PTS.   4# DAYS W/ RAIN  106.0 MEAN RAIN 18.73
 RW CLASS  5 FLOW    547. % DRAINED 100.00
 RW TEMP 20.40 BOD    3.0 SS  200.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CMAT 0.0720
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SEQ NO 160 U.A NO.  53901 UA NAME AKRON OH                     CSC AREA    9573. CSO POP   254000.
UA POP   542775. UA SIZE  203.5 70 SMSA POP   679239.
2000 SMSA POP   792300. NO.CSO PTS.  37# DAYS W/ RAIN  141.0 MEAN RAIN 37.26
 RW CLASS  3 FLOW      95. % DRAINED  85.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   40.0 ALK   15.0 PH 6.90
 COST FACTOR 1.0744 CNAT 0.4970


SEQ NO 161 U.A NO.  53902 UA NAME CANTON OH                    CSC AREA       0. CSO POP        0.
UA POP   244279. UA SIZE   77.2 70 SMSA POP   393789.
2000 SMSA POP   404100. NO.CSO PTS.   0# DAYS W/ RAIN  141.0 MEAN RAIN 37.26
 RW CLASS  1 FLOW      34. % DRAINED  90.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   40.0 ALK   15.0 PH 6.90
 COST FACTOR 1.0744 CNAT 0.3860


SEQ NO 162 U.A NO.  53903 UA NAME CINCINNATI OH                CSC AREA   56650. CSO POP   534100.
UA POP   913536. UA SIZE  275.2 70 SMSA POP  1387207.
2000 SMSA POP  1738000. NO.CSO PTS. 216# DAYS W/ RAIN  134.0 MEAN RAIN 39.34
 RW CLASS  4 FLOW       0. % DRAINED 100.00
 RW TEMP 24.30 BOD    2.0 SS   40.0 PB 0.0167 HARD  100.0 ALK   20.0 PH 7.50
 COST FACTOR 1.0415 CNAT 0.3860


SEQ NO 163 U.A NO.  53904 UA NAME CLEVELAND OH                 CSC AREA   48342. CSO POP   669600.
UA POP  1959879. UA SIZE  646.1 70 SMSA POP  2063729.
2000 SMSA POP  2470600. NO.CSO PTS. 545# DAYS W/ RAIN  156.0 MEAN RAIN 32.08
 RW CLASS  8 FLOW       0. % DRAINED 100.00
 RW TEMP 21.60 BOD    1.0 SS   20.0 PB 0.0167 HARD   50.0 ALK   20.0 PH 7.00
 COST FACTOR 1.0744 CNAT 0.4970


SEQ NO 164 U.A NO.  53905 UA NAME COLUMBUS OH                  CSC AREA   27490. CSO POP   350000.
UA POP   790019. UA SIZE  234.5 70 SMSA POP  1017847.
2000 SMSA POP  1475400. NO.CSO PTS.  57# DAYS W/ RAIN  140.0 MEAN RAIN 34.36
 RW CLASS  3 FLOW    1369. % DRAINED 100.00
 RW TEMP 23.80 BOD    2.0 SS   20.0 PB 0.0167 HARD  100.0 ALK   20.0 PH 7.50
 COST FACTOR 1.0415 CNAT 0.3860


SEQ NO 165 U.A NO.  53906 UA NAME DAYTON OH                    CSC AREA    4480. CSO POP    11470.
UA POP   685942. UA SIZE  224.2 70 SMSA POP   852531.
2000 SMSA POP  1152700. NO.CSO PTS.   6# DAYS W/ RAIN  132.0 MEAN RAIN 35.15
 RW CLASS  6 FLOW    4748. % DRAINED  85.00
 RW TEMP 23.80 BOD    2.0 SS   40.0 PB 0.0167 HARD  100.0 ALK   20.0 PH 7.50
 COST FACTOR 1.0415 CNAT 0.3860
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SEQ NO 166 U.A NO.  53907 UA NAME HAMILTON OH
UA POP    90912. UA SIZE   38.2 70 SMSA POP   226207.           CSO AREA       0. CSO POP        0.
2000 SMSA POP   294700. NO.CSO PTS.   0# DAYS W/ RAIN  134.0 MEAN RAIN 39.85
 RW CLASS  6 FLOW   3185. % DRAINED 100.00
 RW TEMP 23.80 BOD    2.5 SS   80.0 PB 0.0167 HARD  150.0 ALK   75.0 PH 8.00
 COST FACTOR 1.0415 CRAT 0.3860


SEQ NO 167 U.A NO.  53908 UA NAME HUNTINGTON METRO OH       CSO AREA    2100. CSO POP    15700.
UA POP    29250. UA SIZE   13.8 70 SMSA POP   286935.
2000 SMSA POP   262700. NO.CSO PTS.   9# DAYS W/ RAIN  136.0 MEAN RAIN 41.79
 RW CLASS  5 FLOW 174180. % DRAINED 100.00
 RW TEMP 24.30 BOD    1.0 SS   20.0 PB 0.0167 HARD   50.0 ALK   10.0 PH 7.00
 COST FACTOR 1.0415 CRAT 0.3860


SEQ NO 168 U.A NO.  53909 UA NAME LIMA OH
UA POP    70295. UA SIZE   27.4 70 SMSA POP   210074.           CSO AREA    6470. CSO POP    47800.
2000 SMSA POP   211100. NO.CSO PTS.  48# DAYS W/ RAIN  132.0 MEAN RAIN 36.28
 RW CLASS  2 FLOW    125. % DRAINED 100.00
 RW TEMP 22.70 BOD    2.0 SS   80.0 PB 0.0167 HARD  150.0 ALK  100.0 PH 7.80
 COST FACTOR 1.0415 CRAT 0.4970


SEQ NO 169 U.A NO.  53910 UA NAME LORAIN-ELYRIA OH           CSO AREA     220. CSO POP     2540.
UA POP   192265. UA SIZE  106.4 70 SMSA POP   256843.
2000 SMSA POP   330400. NO.CSO PTS.  19# DAYS W/ RAIN  156.0 MEAN RAIN 34.03
 RW CLASS  3 FLOW    319. % DRAINED 100.00
 RW TEMP 21.60 BOD    1.0 SS   20.0 PB 0.0167 HARD   50.0 ALK   20.0 PH 7.00
 COST FACTOR 1.0774 CRAT 0.4970


SEQ NO 170 U.A NO.  53911 UA NAME MANSFIELD OH
UA POP    77599. UA SIZE   40.9 70 SMSA POP   129997.           CSO AREA       0. CSO POP        0.
2000 SMSA POP   164400. NO.CSO PTS.   0# DAYS W/ RAIN  141.0 MEAN RAIN 33.93
 RW C[illegible]  3 FLOW      5. % DRAINED 100.00
 RW T[illegible] 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   50.0 ALK   20.0 PH 7.00
 COST FACTOR 1.0774 CRAT 0.4970


SEQ NO 171 U.A NO.  53912 UA NAME SPRINGFIELD OH
UA POP    93653. UA SIZE   25.3 70 SMSA POP   187606.           CSO AREA    5200. CSO POP    72280.
2000 SMSA POP   176500. NO.CSO PTS.  64# DAYS W/ RAIN  132.0 MEAN RAIN 38.07
 RW CLASS  3 FLOW    481. % DRAINED 100.00
 RW TEMP 23.80 BOD    2.5 SS   80.0 PB 0.0167 HARD  150.0 ALK   75.0 PH 7.80
 COST FACTOR 1.0415 CRAT 0.3860
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SEQ NO 172 U.A NO.  53913 UA NAME STEUBENVILLE OH
UA POP    48262. UA SIZE   12.3 70 SMSA POP   166385.       CSC AREA    4000. CSO POP    39000.
2000 SMSA POP   146900. NO.CSO PTS.  15# DAYS W/ RAIN  146.0 MEAN RAIN 40.83
 RW CLASS  4 FLOW   3234. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   40.0 ALK   12.0 PH 6.90
 COST FACTOR 1.0415 CMAT 0.3860


SEQ NO 173 U.A NO.  53914 UA NAME TOLEDO OH
UA POP   475928. UA SIZE  158.6 70 SMSA POP   762658.       CSC AREA   25924. CSO POP   232534.
2000 SMSA POP   900100. NO.CSO PTS. 125# DAYS W/ RAIN  131.0 MEAN RAIN 31.84
 RW CLASS  3 FLOW   4786. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.5 SS   20.0 PB 0.0167 HARD   85.0 ALK   75.0 PH 7.50
 COST FACTOR 1.0415 CMAT 0.4970


SEQ NO 174 U.A NO.  53915 UA NAME WHEELING METRO OH
UA POP    32239. UA SIZE    6.9 70 SMSA POP   181954.       CSC AREA     800. CSO POP    14039.
2000 SMSA POP   167900. NO.CSO PTS.  23# DAYS W/ RAIN  146.0 MEAN RAIN 38.95
 RW CLASS  4 FLOW  69430. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   40.0 ALK   10.0 PH 6.90
 COST FACTOR 1.0413 CMAT 0.3860


SEQ NO 175 U.A NO.  53916 UA NAME YOUNGSTOWN OH
UA POP   395540. UA SIZE  128.6 70 SMSA POP   537124.       CSC AREA   12262. CSO POP    74325.
2000 SMSA POP   627500. NO.CSO PTS. 131# DAYS W/ RAIN  166.0 MEAN RAIN 41.33
 RW CLASS  3 FLOW    852. % DRAINED 100.00
 RW TEMP 21.60 BOD    1.0 SS   20.0 PB 0.0167 HARD   40.0 ALK   18.0 PH 6.90
 COST FACTOR 1.0415 CMAT 0.3860


SEQ NO 315 U.A NO.  53917 UA NAME PARKERSBURG METRO OH     CSC AREA       0. CSO POP        0.
UA POP     7189. UA SIZE    3.2 70 SMSA POP   148132.
2000 SMSA POP   220400. NO.CSO PTS.   0# DAYS W/ RAIN  143.0 MEAN RAIN 39.11
 RW CLASS  4 FLOW  69430. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS   32.0 PB 0.0167 HARD   35.0 ALK   10.0 PH 7.00
 COST FACTOR 1.0413 CMAT 0.3860


SEQ NO 196 U.A NO.  64001 UA NAME FORT SMITH METRO OK      CSC AREA       0. CSO POP        0.
UA POP     2098. UA SIZE    2.7 70 SMSA POP   160421.
2000 SMSA POP   213800. NO.CSO PTS.   0# DAYS W/ RAIN   93.0 MEAN RAIN 42.22
 RW CLASS  2 FLOW    372. % DRAINED 100.00
 RW TEMP 26.60 BOD    1.0 SS  200.0 PB 0.0167 HARD   20.0 ALK   75.0 PH 8.00
 COST FACTOR 0.7934 CMAT 0.3300
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SEQ NO 197 U.A NO.  64002 UA NAME LAWTON OK              CSO AREA       0. CSO POP        0.
UA POP    55687. UA SIZE   44.0 70 SMSA POP   108144.
2000 SMSA POP   108100. NO.CSO PTS.   0# DAYS W/ RAIN   82.0 MEAN RAIN 30.18
 RW CLASS  2 FLOW       0. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS  220.0 PB 0.0167 HARD   30.0 ALK   45.0 PH 7.50
 COST FACTOR 0.7934 CWAT 0.0820


SEQ NO 198 U.A NO.  64003 UA NAME OKLAHOMA CITY OK       CSO AREA       0. CSO POP        0.
UA POP   579788. UA SIZE  339.1 70 SMSA POP   699092.
2000 SMSA POP  1028300. NO.CSO PTS.   0# DAYS W/ RAIN   82.0 MEAN RAIN 32.58
 RW CLASS  2 FLOW     103. % DRAINED  65.00
 RW TEMP 27.10 BOD    1.0 SS  240.0 PB 0.0167 HARD   30.0 ALK   50.0 PH 7.50
 COST FACTOR 0.7934 CWAT 0.0820


SEQ NO 199 U.A NO.  64004 UA NAME TULSA OK               CSO AREA       0. CSO POP        0.
UA POP   371499. UA SIZE  180.1 70 SMSA POP   549154.
2000 SMSA POP   616700. NO.CSO PTS.   0# DAYS W/ RAIN   90.0 MEAN RAIN 37.08
 RW CLASS  4 FLOW    6554. % DRAINED 100.00
 RW TEMP 26.60 BOD    1.0 SS  280.0 PB 0.0117 HARD   30.0 ALK   50.0 PH 7.50
 COST FACTOR 0.7934 CWAT 0.0820


SEQ NO 280 U.A NO. 104101 UA NAME EUGENE OR              CSO AREA       0. CSO POP        0.
UA POP   139255. UA SIZE   55.3 70 SMSA POP   215401.
2000 SMSA POP   272100. NO.CSO PTS.   0# DAYS W/ RAIN  143.0 MEAN RAIN 37.51
 RW CLASS  5 FLOW    1711. % DRAINED 100.00
 RW TEMP 15.40 BOD    0.5 SS    8.0 PB 0.0100 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CWAT 0.5300


SEQ NO 281 U.A NO. 104102 UA NAME PORTLAND OR            CSO AREA   12420. CSO POP   325351.
UA POP   751756. UA SIZE  236.2 70 SMSA POP  1007130.
2000 SMSA POP  1391300. NO.CSO PTS.  73# DAYS W/ RAIN  149.0 MEAN RAIN 39.91
 RW CLASS  5 FLOW   38420. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.6 SS   20.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CWAT 0.5300


SEQ NO 282 U.A NO. 104103 UA NAME SALEM OR               CSO AREA    6100. CSO POP    60187.
UA POP    93041. UA SIZE   36.8 70 SMSA POP   186658.
2000 SMSA POP   257300. NO.CSO PTS.  18# DAYS W/ RAIN  151.0 MEAN RAIN 39.85
 RW CLASS  5 FLOW 238600. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.5 SS   20.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CWAT 0.5300
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SEQ NO  48 U.A NO.  34201 UA NAME ALLENTOWN PA               CSC AREA     170. CSO POP      800.
UA POP   338316. UA SIZE   91.6 70 SMSA POP   594382.
2000 SMSA POP   624300. NC.CSO PTS.   4# DAYS W/ RAIN  122.0 MEAN RAIN 44.12
 RW CLASS  1 FLOW     96. % DRAINED 100.00
 RW TEMP 21.60 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.60
 COST FACTOR 1.1722 CBAT 0.3910


SEQ NO  49 U.A NO.  34202 UA NAME ALTOONA PA                 CSC AREA    2500. CSO POP    45000.
UA POP    81795. UA SIZE   19.6 70 SMSA POP   135356.
2000 SMSA POP   159800. NC.CSO PTS.   3# DAYS W/ RAIN  142.0 MEAN RAIN 43.83
 RW CLASS  2 FLOW    367. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.60
 COST FACTOR 0.9703 CBAT 0.3910


SEQ NO  50 U.A NO.  34203 UA NAME ERIE PA                    CSC AREA   16120. CSO POP   136066.
UA POP   175263. UA SIZE   43.8 70 SMSA POP   263654.
2000 SMSA POP   356600. NC.CSO PTS.  24# DAYS W/ RAIN  157.0 MEAN RAIN 37.50
 RW CLASS 12 FLOW      0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   25.0 ALK   10.0 PH 6.90
 COST FACTOR 1.2171 CBAT 0.4970


SEQ NO  51 U.A NO.  34204 UA NAME HARRISBURG PA              CSC AREA   16580. CSO POP    69350.
UA POP   240751. UA SIZE   78.4 70 SMSA POP   410505.
2000 SMSA POP   569200. NC.CSO PTS.  47# DAYS W/ RAIN  124.0 MEAN RAIN 37.65
 RW CLASS  5 FLOW  34250. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.60
 COST FACTOR 1.1818 CBAT 0.3910


SEQ NO  52 U.A NO.  34205 UA NAME JOHNSTOWN PA               CSC AREA       0. CSO POP        0.
UA POP    96146. UA SIZE   28.0 70 SMSA POP   262822.
2000 SMSA POP   246700. NC.CSO PTS.   0# DAYS W/ RAIN  150.0 MEAN RAIN 44.77
 RW CLASS  4 FLOW    324. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 6.60
 COST FACTOR 0.9703 CBAT 0.3910


SEQ NO  53 U.A NO.  34206 UA NAME LANCASTER PA               CSC AREA    2851. CSO POP    57690.
UA POP   117097. UA SIZE   38.7 70 SMSA POP   320079.
2000 SMSA POP   426700. NC.CSO PTS.   2# DAYS W/ RAIN  124.0 MEAN RAIN 43.29
 RW CLASS  1 FLOW      0. % DRAINED 65.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.50
 COST FACTOR 0.9316 CBAT 0.3910
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SEQ NO  54 U.A NO.  34207 UA NAME PHILADELPHIA PA          CSC AREA   45600. CSO POP  1926176.
UA POP  3277020. UA SIZE  702.7 70 SMSA POP  4824110.
2000 SMSA POP  6015800. NO.CSO PTS. 178# DAYS W/ RAIN  115.0 MEAN RAIN 42.48
 RW CLASS 13 FLOW  11430. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.1818 CRAT 0.4620


SEQ NO  55 U.A NO.  34208 UA NAME PITTSBURG PA             CSC AREA   59417. CSO POP   957844.
UA POP  1846041. UA SIZE  596.4 70 SMSA POP  2401362.
2000 SMSA POP  2539000. NO.CSO PTS. 266# DAYS W/ RAIN  146.0 MEAN RAIN 36.87
 RW CLASS  4 FLOW  32340. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   25.0 ALK   10.0 PH 6.80
 COST FACTOR 1.0413 CRAT 0.3860


SEQ NO  56 U.A NO.  34209 UA NAME READING PA               CSC AREA       0. CSO POP        0.
UA POP   167932. UA SIZE   41.1 70 SMSA POP   296382.
2000 SMSA POP   347300. NO.CSO PTS.   0# DAYS W/ RAIN  120.0 MEAN RAIN 41.43
 RW CLASS  3 FLOW   1490. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.50
 COST FACTOR 0.9316 CRAT 0.3910


SEQ NO  57 U.A NO.  34210 UA NAME SCRANTON PA              CSC AREA   14119. CSO POP   110000.
UA POP   204205. UA SIZE   98.4 70 SMSA POP   621882.
2000 SMSA POP   305100. NO.CSO PTS.  75# DAYS W/ RAIN  137.0 MEAN RAIN 38.48
 RW CLASS  3 FLOW    508. % DRAINED 100.00
 RW TEMP 22.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.50
 COST FACTOR 0.9703 CRAT 0.3910


SEQ NO  58 U.A NO.  34211 UA NAME TRENTON METRO PA         CSC AREA       0. CSO POP        0.
UA POP    31475. UA SIZE   13.1 70 SMSA POP   304116.
2000 SMSA POP   459400. NO.CSO PTS.   0# DAYS W/ RAIN  121.0 MEAN RAIN 41.28
 RW CLASS  2 FLOW  11660. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.1205 CRAT 0.4620


SEQ NO  59 U.A NO.  34212 UA NAME WILKES-BARRE PA          CSC AREA    5615. CSO POP    71719.
UA POP   222830. UA SIZE   82.5 70 SMSA POP   621882.
2000 SMSA POP   458300. NO.CSO PTS.  50# DAYS W/ RAIN  137.0 MEAN RAIN 39.37
 RW CLASS  5 FLOW  13270. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.50
 COST FACTOR 0.9316 CRAT 0.4620
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SEQ NO  60 U.A NO.  34213 UA NAME YORK PA                    CSO AREA      0. CSO POP        0.
UA POP   123106. UA SIZE   37.3 70 SMSA POP   329540.
2000 SMSA POP   442800. NO.CSO PTS.   0# DAYS W/ RAIN  124.0 MEAN RAIN 42.00
 RW CLASS  2 FLOW     245. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.60
 COST FACTOR 1.1818 CRAT 0.3910


SEQ NO 313 U.A NO.  34214 UA NAME WILLIAMSPORT PA            CSO AREA   4500. CSO POP    35000.
UA POP    63880. UA SIZE   21.7 70 SMSA POP   113296.
2000 SMSA POP   120300. NO.CSO PTS.   0# DAYS W/ RAIN  142.0 MEAN RAIN 40.65
 RW CLASS  3 FLOW   8864. % DRAINED 100.00
 RW TEMP 22.70 BOD    1.0 SS   20.0 PB 0.0167 HARD   18.0 ALK   10.0 PH 6.70
 COST FACTOR 0.9703 CRAT 0.3910


SEQ NO  28 U.A NO.  14401 UA NAME FALL RIVER METRO RI        CSO AREA      0. CSO POP        0.
UA POP    15901. UA SIZE   12.4 70 SMSA POP   444301.
2000 SMSA POP   494700. NO.CSO PTS.   0# DAYS W/ RAIN  123.0 MEAN RAIN 45.28
 RW CLASS 11 FLOW       0. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1209 CRAT 0.5650


SEQ NO  29 U.A NO.  14402 UA NAME PROVIDENCE RI              CSO AREA  11865. CSO POP   197000.
UA POP   729337. UA SIZE  200.2 70 SMSA POP   855495.
2000 SMSA POP   945500. NO.CSO PTS.  67# DAYS W/ RAIN  123.0 MEAN RAIN 39.63
 RW CLASS  4 FLOW      40. % DRAINED 100.00
 RW TEMP 21.00 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.1209 CRAT 0.5650


SEQ NO 113 U.A NO.  44501 UA NAME AUGUSTA METRO SC           CSO AREA      0. CSO POP        0.
UA POP    22183. UA SIZE   15.6 70 SMSA POP   275787.
2000 SMSA POP   277400. NO.CSO PTS.   0# DAYS W/ RAIN  105.0 MEAN RAIN 39.18
 RW CLASS  5 FLOW  10200. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   24.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.6281 CRAT 0.3060


SEQ NO 114 U.A NO.  44502 UA NAME CHARLESTON SC              CSO AREA      0. CSO POP        0.
UA POP   228399. UA SIZE   99.2 70 SMSA POP   336125.
2000 SMSA POP   332200. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 46.54
 RW CLASS 12 FLOW       0. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.6281 CRAT 0.3060
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SEQ NO 115 U.A NO.  44503 UA NAME COLUMBIA SC             CSC AREA      0. CSO POP        0.
UA POP   241781. UA SIZE  103.3 70 SMSA POP   322880.
2000 SMSA POP   486700. NO.CSO PTS.   0# DAYS W/ RAIN  109.0 MEAN RAIN 46.82
 RW CLASS  3 FLOW    9371. % DRAINED 100.00
 RW TEMP 23.80 BOD     1.0 SS   24.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.6281 CRAT 0.3060

SEQ NO 116 U.A NO.  44504 UA NAME GREENVILLE SC           CSC AREA      0. CSO POP        0.
UA POP   157073. UA SIZE   70.9 70 SMSA POP   473454.
2000 SMSA POP   480000. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 46.42
 RW CLASS  2 FLOW     347. % DRAINED  95.00
 RW TEMP 27.10 BOD     0.6 SS   40.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.80
 COST FACTOR 0.6281 CRAT 0.3060

SEQ NO 305 U.A NO.  44505 UA NAME SPARTANBURG SC          CSC AREA      0. CSO POP        0.
UA POP    73638. UA SIZE   36.1 70 SMSA POP   473454.
2000 SMSA POP   250440. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 49.69
 RW CLASS  4 FLOW    4049. % DRAINED  50.00
 RW TEMP 27.10 BOD     0.6 SS   40.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 0.6281 CRAT 0.3060

SEQ NO 253 U.A NO.  84601 UA NAME SIOUX CITY METRO SD     CSC AREA      0. CSO POP        0.
UA POP      860. UA SIZE    0.7 70 SMSA POP    95209.
2000 SMSA POP   109600. NO.CSO PTS.   0# DAYS W/ RAIN   98.0 MEAN RAIN 24.77
 RW CLASS  4 FLOW  33126. % DRAINED 100.00
 RW TEMP 23.20 BOD     2.5 SS  240.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CRAT 0.0720

SEQ NO 254 U.A NO.  84602 UA NAME SIOUX FALLS SD          CSC AREA    200. CSO POP     2000.
UA POP    75146. UA SIZE   26.9 70 SMSA POP    95209.
2000 SMSA POP   115700. NO.CSO PTS.   0# DAYS W/ RAIN   93.0 MEAN RAIN 25.24
 RW CLASS  4 FLOW     364. % DRAINED 100.00
 RW TEMP 22.70 BOD     3.0 SS  240.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CRAT 0.0720

SEQ NO 117 U.A NO.  44701 UA NAME CHATTANOOGA TN          CSC AREA   2707. CSO POP    15600.
UA POP   194633. UA SIZE   99.5 70 SMSA POP   370857.
2000 SMSA POP   484200. NO.CSO PTS.  17# DAYS W/ RAIN  131.0 MEAN RAIN 53.60
 RW CLASS  6 FLOW  37180. % DRAINED 100.00
 RW TEMP 25.40 BOD     0.6 SS   28.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 7.20
 COST FACTOR 0.8389 CRAT 0.4130
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SEQ NO 118 U.A NO.  44702 UA NAME KNOXVILLE TN                      CSO AREA        0. CSO POP          0.
UA POP    190502. UA SIZE   86.1 70 SMSA POP   409409.
2000 SMSA POP   527000. NO.CSO PTS.    0# DAYS W/ RAIN  132.0 MEAN RAIN 45.51
 RW CLASS  4 FLOW  13070. % DRAINED 100.00
 RW TEMP 23.80 BOD     1.0 SS   28.0 PB 0.0167 HARD   50.0 ALK   10.0 PH 7.20
 COST FACTOR 0.8289 CHAT 0.4130


SEQ NO 119 U.A NO.  44703 UA NAME MEMPHIS TN                        CSO AREA        0. CSO POP          0.
UA POP   655045. UA SIZE  192.3 70 SMSA POP   834103.
2000 SMSA POP  1112700. NO.CSO PTS.    0# DAYS W/ RAIN  112.0 MEAN RAIN 46.81
 RW CLASS  5 FLOW 470800. % DRAINED 100.00
 RW TEMP 26.70 BOD     1.0 SS   60.0 PB 0.0067 HARD   50.0 ALK  100.0 PH 7.50
 COST FACTOR 0.8289 CHAT 0.3270


SEQ NO 120 U.A NO.  44704 UA NAME NASHVILLE TN                      CSO AREA    11000. CSO POP     100900.
UA POP   484444. UA SIZE  343.5 70 SMSA POP   699271.
2000 SMSA POP   872200. NO.CSO PTS.   32# DAYS W/ RAIN  120.0 MEAN RAIN 45.40
 RW CLASS  4 FLOW  19000. % DRAINED 100.00
 RW TEMP 25.40 BOD     2.4 SS   60.0 PB 0.0167 HARD  100.0 ALK  100.0 PH 7.80
 COST FACTOR 0.8289 CHAT 0.4130


SEQ NO 295 U.A NO.  44705 UA NAME KINGSPORT TN                      CSO AREA        0. CSO POP          0.
UA POP    66266. UA SIZE   46.5 70 SMSA POP   373591.
2000 SMSA POP   625000. NO.CSO PTS.    0# DAYS W/ RAIN  132.0 MEAN RAIN 42.34
 RW CLASS  4 FLOW   2603. % DRAINED 100.00
 RW TEMP 23.80 BOD     0.5 SS   40.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 6.90
 COST FACTOR 1.0415 CHAT 0.4130


SEQ NO 301 U.A NO.  44706 UA NAME CLARKSVILLE TN                    CSO AREA        0. CSO POP          0.
UA POP    44729. UA SIZE   33.7 70 SMSA POP   118945.
2000 SMSA POP   260000. NO.CSO PTS.    0# DAYS W/ RAIN  120.0 MEAN RAIN 47.46
 RW CLASS  4 FLOW  19000. % DRAINED 100.00
 RW TEMP 26.00 BOD     2.5 SS   72.0 PB 0.0117 HARD  100.0 ALK  200.0 PH 8.00
 COST FACTOR 1.0415 CHAT 0.4130


SEQ NO 200 U.A NO.  64801 UA NAME ABILENE TX                        CSO AREA        0. CSO POP          0.
UA POP    90571. UA SIZE   78.4 70 SMSA POP   122164.
2000 SMSA POP   118900. NO.CSO PTS.    0# DAYS W/ RAIN   65.0 MEAN RAIN 23.32
 RW CLASS  2 FLOW     48. % DRAINED 100.00
 RW TEMP 27.70 BOD     1.0 SS  200.0 PB 0.0250 HARD   30.0 ALK   42.0 PH 7.50
 COST FACTOR 0.7934 CHAT 0.1480
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                                                                CSC AREA      0. CSO POP         0.
SEQ NO 201 U.A NO.  64802 UA NAME AMARILLO TX
UA POP    127010. UA SIZE   60.7 70 SMSA POP   144396.
2000 SMSA POP   141600. NO.CSO PTS.   0# DAYS W/ RAIN   66.0 MEAN RAIN 19.67
 RW CLASS  3 FLOW    359. % DRAINED  20.00
 RW TEMP 25.40 BOD    1.0 SS  200.0 PB 0.0333 HARD   40.0 ALK   60.0 PH 7.50
 COST FACTOR 0.7934 CRAT 0.0820

                                                                CSC AREA      0. CSO POP         0.
SEQ NO 202 U.A NO.  64803 UA NAME AUSTIN TX
UA POP    264499. UA SIZE   85.8 70 SMSA POP   360463.
2000 SMSA POP   482900. NO.CSO PTS.   0# DAYS W/ RAIN   81.0 MEAN RAIN 32.58
 RW CLASS  6 FLOW   4536. % DRAINED  95.00
 RW TEMP 29.30 BOD    1.0 SS   40.0 PB 0.0333 HARD   30.0 ALK   30.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480

                                                                CSC AREA   4670. CSO POP     35000.
SEQ NO 203 U.A NO.  64804 UA NAME BEAUMONT TX
UA POP    116350. UA SIZE   74.5 70 SMSA POP   347568.
2000 SMSA POP   424800. NO.CSO PTS.   0# DAYS W/ RAIN  103.6 MEAN RAIN 54.29
 RW CLASS  4 FLOW   6308. % DRAINED  75.00
 RW TEMP 28.80 BOD    1.0 SS   36.0 PB 0.0167 HARD   20.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480

                                                                CSC AREA      0. CSO POP         0.
SEQ NO 204 U.A NO.  64805 UA NAME BROWNSVILLE TX
UA POP     52627. UA SIZE   15.2 70 SMSA POP   140368.
2000 SMSA POP   147200. NO.CSO PTS.   0# DAYS W/ RAIN   71.0 MEAN RAIN 26.75
 RW CLASS  4 FLOW   7901. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   36.0 PB 0.0333 HARD   30.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480

                                                                CSC AREA      0. CSO POP         0.
SEQ NO 205 U.A NO.  64806 UA NAME BRYAN TX
UA POP     51395. UA SIZE   33.4 70 SMSA POP    57978.
2000 SMSA POP   120200. NO.CSO PTS.   0# DAYS W/ RAIN   76.0 MEAN RAIN 40.76
 RW CLASS  2 FLOW      0. % DRAINED  25.00
 RW TEMP 28.80 BOD    1.0 SS   40.0 PB 0.0333 HARD   30.0 ALK   30.0 PH 7.50
 COST FACTOR 0.7934 CRAT 0.1480

                                                                CSC AREA      0. CSO POP         0.
SEQ NO 206 U.A NO.  64807 UA NAME CORPUS CHRISTI TX
UA POP    212820. UA SIZE  130.3 70 SMSA POP   284832.
2000 SMSA POP   330200. NO.CSO PTS.   0# DAYS W/ RAIN   75.0 MEAN RAIN 28.34
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   36.0 PB 0.0333 HARD   30.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480
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SEQ NO 207 U.A NO.  64808 UA NAME DALLAS TX                 CSO AREA       0. CSO POP         0.
UA POP  1338663. UA SIZE  674.2 70 SMSA POP  2378353.
2000 SMSA POP  2521400. NO.CSO PTS.   0# DAYS W/ RAIN   80.0 MEAN RAIN 34.55
 RW CLASS  4 FLOW       0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS  140.0 PB 0.0167 HARD   20.0 ALK   40.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 208 U.A NO.  64809 UA NAME EL PASO TX                CSO AREA       0. CSO POP         0.
UA POP   337471. UA SIZE  119.4 70 SMSA POP   359291.
2000 SMSA POP   365400. NO.CSO PTS.   0# DAYS W/ RAIN   44.0 MEAN RAIN  7.89
 RW CLASS  0 FLOW       0. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   36.0 PB 0.0333 HARD   40.0 ALK   60.0 PH 7.50
 COST FACTOR 0.8678 CMAT 0.1480


SEQ NO 209 U.A NO.  64810 UA NAME FORT WORTH TX             CSO AREA       0. CSO POP         0.
UA POP   676944. UA SIZE  396.4 70 SMSA POP   237853.
2000 SMSA POP  1068300. NO.CSO PTS.   0# DAYS W/ RAIN   79.0 MEAN RAIN 31.33
 RW CLASS  2 FLOW     372. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   80.0 PB 0.0117 HARD   18.0 ALK   50.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 210 U.A NO.  64811 UA NAME GALVESTON TX              CSO AREA       0. CSO POP         0.
UA POP    61809. UA SIZE   22.5 70 SMSA POP   169812.
2000 SMSA POP   260400. NO.CSO PTS.   0# DAYS W/ RAIN   96.0 MEAN RAIN 45.21
 RW CLASS 15 FLOW       0. % DRAINED 100.00
 RW TEMP 28.30 BOD    1.0 SS   36.0 PB 0.0250 HARD   20.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8675 CMAT 0.1480


SEQ NO 211 U.A NO.  64812 UA NAME HARLINGEN TX              CSO AREA       0. CSO POP         0.
UA POP    50469. UA SIZE   33.8 70 SMSA POP   140368.
2000 SMSA POP   147200. NO.CSO PTS.   0# DAYS W/ RAIN   71.0 MEAN RAIN 26.09
 RW CLASS  4 FLOW       0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   36.0 PB 0.0333 HARD   30.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CMAT 0.1480


SEQ NO 212 U.A NO.  64813 UA NAME HOUSTEN TX                CSO AREA       0. CSO POP         0.
UA POP  1677862. UA SIZE  538.6 70 SMSA POP  1999316.
2000 SMSA POP  3256900. NO.CSO PTS.   0# DAYS W/ RAIN  103.0 MEAN RAIN 45.26
 RW CLASS  4 FLOW     274. % DRAINED  80.00
 RW TEMP 28.30 BOD    1.0 SS   36.0 PB 0.0025 HARD   20.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CMAT 0.1480
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SEQ NO 213 U.A NO.  64814 UA NAME LAREDO TX                 CSO AREA       0. CSO POP         0.
UA POP    70197. UA SIZE   22.1 70 SMSA POP    72859.
2000 SMSA POP    78200. NO.CSO PTS.   0# DAYS W/ RAIN   79.0 MEAN RAIN 18.63
 RW CLASS  3 FLOW   5382. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   40.0 PB 0.0333 HARD   30.0 ALK   30.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480


SEQ NO 214 U.A NO.  64815 UA NAME LUBBOCK TX                CSO AREA       0. CSO POP         0.
UA POP   150135. UA SIZE   76.9 70 SMSA POP   179295.
2000 SMSA POP   171000. NO.CSO PTS.   0# DAYS W/ RAIN   60.0 MEAN RAIN 17.67
 RW CLASS  2 FLOW      0. % DRAINED 100.00
 RW TEMP 26.60 BOD    1.0 SS   80.0 PB 0.0333 HARD   40.0 ALK   48.0 PH 7.50
 COST FACTOR 0.7934 CRAT 0.1480


SEQ NO 215 U.A NO.  64816 UA NAME MCALLEN-PHARR TX          CSO AREA       0. CSO POP         0.
UA POP    91141. UA SIZE   32.7 70 SMSA POP   181535.
2000 SMSA POP   163600. NO.CSO PTS.   0# DAYS W/ RAIN   71.0 MEAN RAIN 19.29
 RW CLASS  3 FLOW      0. % DRAINED 100.00
 RW TEMP 29.30 BOD    1.0 SS   36.0 PB 0.0333 HARD   20.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480


SEQ NO 216 U.A NO.  64817 UA NAME MIDLAND TX                CSO AREA       0. CSO POP         0.
UA POP    60371. UA SIZE   32.0 70 SMSA POP    65433.
2000 SMSA POP    64600. NO.CSO PTS.   0# DAYS W/ RAIN   50.0 MEAN RAIN 14.24
 RW CLASS  1 FLOW      0. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   72.0 PB 0.0333 HARD   35.0 ALK   48.0 PH 7.50
 COST FACTOR 0.7934 CRAT 0.1480


SEQ NO 217 U.A NO.  64818 UA NAME ODESSA TX                 CSO AREA       0. CSO POP         0.
UA POP    81645. UA SIZE   25.1 70 SMSA POP    92660.
2000 SMSA POP    90800. NO.CSO PTS.   0# DAYS W/ RAIN   50.0 MEAN RAIN 14.24
 RW CLASS  1 FLOW      0. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   72.0 PB 0.0333 HARD   35.0 ALK   48.0 PH 7.50
 COST FACTOR 0.7934 CRAT 0.1480


SEQ NO 218 U.A NO.  64819 UA NAME PORT ARTHUR TX            CSO AREA       0. CSO POP         0.
UA POP   116474. UA SIZE   73.0 70 SMSA POP   347568.
2000 SMSA POP   424800. NO.CSO PTS.   0# DAYS W/ RAIN  103.0 MEAN RAIN 55.35
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 28.80 BOD    1.0 SS   36.0 PB 0.0167 HARD   20.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CRAT 0.1480
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SEQ NO 219 U.A NO.  64820 UA NAME SAN ANGELO TX             CSO AREA      0. CSO POP         0.
UA POP    63884. UA SIZE   33.7 70 SMSA POP    71047.
2000 SMSA POP   905000. NO.CSO PTS.   0# DAYS W/ RAIN   55.0 MEAN RAIN 18.63
 RW CLASS  4 FLOW     158. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   72.0 PB 0.0333 HARD   35.0 ALK   48.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 220 U.A NO.  64821 UA NAME SAN ANTONIO TX            CSO AREA      0. CSO POP         0.
UA POP   772513. UA SIZE  222.9 70 SMSA POP   888179.
2000 SMSA POP  1022000. NO.CSO PTS.   0# DAYS W/ RAIN   79.0 MEAN RAIN 27.84
 RW CLASS  3 FLOW      39. % DRAINED  85.00
 RW TEMP 29.30 BOD    1.0 SS   40.0 PB 0.0333 HARD   30.0 ALK   30.0 PH 7.50
 COST FACTOR 0.8678 CMAT 0.1480


SEQ NO 221 U.A NO.  64822 UA NAME SHERMAN TX                CSO AREA      0. CSO POP         0.
UA POP    55343. UA SIZE   34.5 70 SMSA POP    83225.
2000 SMSA POP   115600. NO.CSO PTS.   0# DAYS W/ RAIN   80.0 MEAN RAIN 39.05
 RW CLASS  2 FLOW       0. % DRAINED  70.00
 RW TEMP 27.10 BOD    1.0 SS  200.0 PB 0.0200 HARD   22.0 ALK   45.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 222 U.A NO.  64823 UA NAME TEXARKANA TX              CSO AREA      0. CSO POP         0.
UA POP    36888. UA SIZE   24.0 70 SMSA POP   113488.
2000 SMSA POP   130300. NO.CSO PTS.   0# DAYS W/ RAIN   98.0 MEAN RAIN 49.19
 RW CLASS  2 FLOW       0. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS   80.0 PB 0.0117 HARD   18.0 ALK   50.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 223 U.A NO.  64824 UA NAME TEXAS CITY TX             CSO AREA      0. CSO POP         0.
UA POP    84054. UA SIZE   82.7 70 SMSA POP   169812.
2000 SMSA POP   260400. NO.CSO PTS.   0# DAYS W/ RAIN   96.0 MEAN RAIN 45.21
 RW CLASS 10 FLOW       0. % DRAINED 100.00
 RW TEMP 28.30 BOD    1.0 SS   36.0 PB 0.0250 HARD   20.0 ALK   25.0 PH 7.50
 COST FACTOR 0.8678 CMAT 0.1480


SEQ NO 224 U.A NO.  64825 UA NAME TYLER TX                  CSO AREA      0. CSO POP         0.
UA POP    59781. UA SIZE   24.8 70 SMSA POP    97096.
2000 SMSA POP   145200. NO.CSO PTS.   0# DAYS W/ RAIN   80.0 MEAN RAIN 46.78
 RW CLASS  2 FLOW       0. % DRAINED  40.00
 RW TEMP 27.70 BOD    1.0 SS   80.0 PB 0.0200 HARD   18.0 ALK   48.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480
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SEQ NO 225 U.A NO.  64826 UA NAME WACO TX                    CSC AREA       0. CSO POP         0.
UA POP    118843. UA SIZE   89.9 70 SMSA POP   147553.
2000 SMSA POP   193600. NO.CSO PTS.    0# DAYS W/ RAIN   76.0 MEAN RAIN 32.08
 RW CLASS  6 FLOW   2560. % DRAINED  80.00
 RW TEMP 27.70 BOD    1.0 SS   80.0 PB 0.0250 HARD   22.0 ALK   40.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 226 U.A NO.  64827 UA NAME WICHITA FALLS TX           CSC AREA       0. CSO POP         0.
UA POP     97564. UA SIZE   42.2 70 SMSA POP   128642.
2000 SMSA POP   128900. NO.CSO PTS.    0# DAYS W/ RAIN   69.0 MEAN RAIN 26.20
 RW CLASS  5 FLOW    285. % DRAINED 100.00
 RW TEMP 27.10 BOD    1.0 SS  200.0 PB 0.0250 HARD   30.0 ALK   45.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 300 U.A NO.  64828 UA NAME KILLEEN TX                 CSC AREA       0. CSO POP         0.
UA POP     73585. UA SIZE   40.3 70 SMSA POP   159794.
2000 SMSA POP   176300. NO.CSO PTS.    0# DAYS W/ RAIN   76.0 MEAN RAIN 33.94
 RW CLASS  2 FLOW      0. % DRAINED 100.00
 RW TEMP 27.70 BOD    1.0 SS   80.0 PB 0.0250 HARD   22.0 ALK   40.0 PH 7.50
 COST FACTOR 0.7934 CMAT 0.1480


SEQ NO 255 U.A NO.  84901 UA NAME OGDEN UT                   CSC AREA       0. CSO POP         0.
UA POP    149727. UA SIZE   61.0 70 SMSA POP   705458.
2000 SMSA POP   171500. NO.CSO PTS.    0# DAYS W/ RAIN   87.0 MEAN RAIN 17.07
 RW CLASS 20 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   60.0 PB 0.0067 HARD  150.0 ALK  150.0 PH 8.00
 COST FACTOR 0.8843 CMAT 0.0880


SEQ NO 256 U.A NO.  84902 UA NAME PROVO UT                   CSC AREA       0. CSO POP         0.
UA POP    104110. UA SIZE   65.0 70 SMSA POP   137776.
2000 SMSA POP   189800. NO.CSO PTS.    0# DAYS W/ RAIN   87.0 MEAN RAIN 13.20
 RW CLASS  2 FLOW    376. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   60.0 PB 0.0067 HARD  150.0 ALK  200.0 PH 8.00
 COST FACTOR 0.8843 CMAT 0.0880


SEQ NO 257 U.A NO.  84903 UA NAME SALT LAKE CITY UT          CSC AREA       0. CSO POP         0.
UA POP    479342. UA SIZE  184.3 70 SMSA POP   705458.
2000 SMSA POP   791300. NO.CSO PTS.    0# DAYS W/ RAIN   87.0 MEAN RAIN 14.74
 RW CLASS  2 FLOW    113. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   60.0 PB 0.0067 HARD  150.0 ALK  150.0 PH 8.00
 COST FACTOR 0.8843 CMAT 0.0880
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URBANIZED AREA DATA BASE LISTING

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SEQ NO  61 U.A NO.  35101 UA NAME LYNCHBURG VA              CSC AREA   10425. CSO POP    54000.
UA POP    70842. UA SIZE   37.2 70 SMSA POP   133258.
2000 SMSA POP   194100. NO.CSO PTS.  90# DAYS W/ RAIN  119.0 MEAN RAIN 40.30
 RW CLASS  4 FLOW   3538. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   40.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.60
 COST FACTOR 1.0083 CNAT 0.3060


SEQ NO  62 U.A NO.  35102 UA NAME NEWPORT NEWS VA           CSC AREA     268. CSO POP     4500.
UA POP   268263. UA SIZE  143.3 70 SMSA POP   333140.
2000 SMSA POP   352800. NO.CSO PTS.   1# DAYS W/ RAIN  114.0 MEAN RAIN 41.95
 RW CLASS 14 FLOW   7431. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.0083 CNAT 0.3060


SEQ NO  63 U.A NO.  35103 UA NAME NORFOLK VA                CSC AREA       0. CSO POP        0.
UA POP   668259. UA SIZE  299.0 70 SMSA POP   732600.
2000 SMSA POP   770400. NO.CSO PTS.   0# DAYS W/ RAIN  114.0 MEAN RAIN 44.94
 RW CLASS 14 FLOW   7431. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.00
 COST FACTOR 1.0083 CNAT 0.3060


SEQ NO  64 U.A NO.  35104 UA NAME PETERSBURG VA             CSC AREA       0. CSO POP        0.
UA POP   100617. UA SIZE   42.4 70 SMSA POP   128809.
2000 SMSA POP   171300. NO.CSO PTS.   0# DAYS W/ RAIN  113.0 MEAN RAIN 44.21
 RW CLASS  4 FLOW   1463. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.20
 COST FACTOR 1.0083 CNAT 0.3060


SEQ NO  65 U.A NO.  35105 UA NAME RICHMOND VA               CSC AREA   10361. CSO POP   352775.
UA POP   416563. UA SIZE  144.6 70 SMSA POP   547542.
2000 SMSA POP   817000. NO.CSO PTS.  46# DAYS W/ RAIN  113.0 MEAN RAIN 44.21
 RW CLASS 14 FLOW   7431. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 1.0083 CNAT 0.3060


SEQ NO  66 U.A NO.  35106 UA NAME ROANOKE VA                CSC AREA       0. CSO POP        0.
UA POP   156621. UA SIZE   66.4 70 SMSA POP   203153.
2000 SMSA POP   279800. NO.CSO PTS.   0# DAYS W/ RAIN  120.0 MEAN RAIN 43.12
 RW CLASS  4 FLOW    370. % DRAINED 100.00
 RW TEMP 25.40 BOD    1.0 SS   40.0 PB 0.0167 HARD   15.0 ALK   10.0 PH 6.70
 COST FACTOR 1.0083 CNAT 0.3060
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URBANIZED AREA DATA BASE LISTING

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SEQ NO  67 U.A NO.  35107 UA NAME WASHINGTON DC MTR VA       CSC AREA       0. CSO POP        0.
UA POP   715841. UA SIZE  185.1 70 SMSA POP  2910111.
2000 SMSA POP  5189600. NO.CSO PTS.   0# DAYS W/ RAIN  107.0 MEAN RAIN 40.78
 RW CLASS 12 FLOW  11900. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   10.0 ALK   10.0 PH 6.50
 COST FACTOR 1.0083 CNAT 0.3910


SEQ NO 296 U.A NO.  35108 UA NAME KINGSPORT METRO VA         CSC AREA       0. CSO POP        0.
UA POP     4076. UA SIZE    2.2 70 SMSA POP   373591.
2000 SMSA POP   625000. NO.CSO PTS.   0# DAYS W/ RAIN  132.0 MEAN RAIN 42.34
 RW CLASS  4 FLOW   2603. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS   40.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 6.90
 COST FACTOR 1.0415 CNAT 0.4130


SEQ NO 283 U.A NO. 105301 UA NAME PORTLAND METRO WA          CSC AREA       0. CSO POP        0.
UA POP    73170. UA SIZE   30.6 70 SMSA POP  1007130.
2000 SMSA POP  1391300. NO.CSO PTS.   0# DAYS W/ RAIN  149.0 MEAN RAIN 39.00
 RW CLASS  5 FLOW  38420. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.6 SS   20.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0862 CNAT 0.5300


SEQ NO 284 U.A NO. 105302 UA NAME SEATTLE WA                 CSC AREA   28978. CSO POP   377980.
UA POP  1238106. UA SIZE  413.1 70 SMSA POP  1424605.
2000 SMSA POP  1822400. NO.CSO PTS. 159# DAYS W/ RAIN  164.0 MEAN RAIN 34.10
 RW CLASS 14 FLOW      0. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.8 SS   20.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CNAT 0.5300


SEQ NO 285 U.A NO. 105303 UA NAME SPOKANE WA                 CSC AREA   25600. CSO POP   160700.
UA POP   229620. UA SIZE   77.8 70 SMSA POP   287487.
2000 SMSA POP   326000. NO.CSO PTS.  31# DAYS W/ RAIN  118.0 MEAN RAIN 17.19
 RW CLASS  5 FLOW   6938. % DRAINED 100.00
 RW TEMP 18.20 BOD    1.0 SS    8.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CNAT 0.5300


SEQ NO 286 U.A NO. 105304 UA NAME TACOMA WA                  CSC AREA     111. CSO POP     1561.
UA POP   332521. UA SIZE  128.7 70 SMSA POP   412344.
2000 SMSA POP   424600. NO.CSO PTS.   0# DAYS W/ RAIN  163.0 MEAN RAIN 40.50
 RW CLASS  9 FLOW      0. % DRAINED 100.00
 RW TEMP 18.20 BOD    0.8 SS   20.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0862 CNAT 0.5300
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URBANIZED AREA DATA BASE LISTING

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SEQ NO 292 U.A NO. 105305 UA NAME RICHLAND-KENNEWICK WA    CSO AREA       0. CSO POP        0.
UA POP    71245. UA SIZE   54.8 70 SMSA POP    93356.
2000 SMSA POP   117000. NO.CSO PTS.   0# DAYS W/ RAIN  106.0 MEAN RAIN  7.49
 RW CLASS  5 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    0.8 SS    8.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CRAT 0.5300


SEQ NO 312 U.A NO. 105306 UA NAME YAKIMA WA                CSO AREA       0. CSO POP        0.
UA POP    64730. UA SIZE   22.2 70 SMSA POP   145212.
2000 SMSA POP   140300. NO.CSO PTS.   0# DAYS W/ RAIN   70.0 MEAN RAIN  7.86
 RW CLASS  3 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.0 SS   12.0 PB 0.0167 HARD   20.0 ALK   50.0 PH 7.50
 COST FACTOR 1.0330 CRAT 0.5300


SEQ NO  68 U.A NO.  35401 UA NAME CHARLESTON WV            CSO AREA    8838. CSO POP   105421.
UA POP   157662. UA SIZE   61.8 70 SMSA POP   257140.
2000 SMSA POP   247700. NO.CSO PTS.  92# DAYS W/ RAIN  152.0 MEAN RAIN 42.36
 RW CLASS  4 FLOW  14780. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS   20.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 6.90
 COST FACTOR 1.0413 CRAT 0.3860


SEQ NO  69 U.A NO.  35402 UA NAME HUNTINGTON WV            CSO AREA   10400. CSO POP    79844.
UA POP    85017. UA SIZE   19.1 70 SMSA POP   286935.
2000 SMSA POP   262700. NO.CSO PTS.   2# DAYS W/ RAIN  136.0 MEAN RAIN 41.79
 RW CLASS  5 FLOW 174180. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   30.0 ALK   10.0 PH 7.00
 COST FACTOR 1.0413 CRAT 0.3860


SEQ NO  70 U.A NO.  35403 UA NAME STEUBENVILLE WTR WV      CSO AREA     240. CSO POP     3450.
UA POP    37230. UA SIZE   26.6 70 SMSA POP   166385.
2000 SMSA POP   146900. NO.CSO PTS.   5# DAYS W/ RAIN  146.0 MEAN RAIN 40.83
 RW CLASS  4 FLOW 323400. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   20.0 ALK   10.0 PH 6.60
 COST FACTOR 1.0413 CRAT 0.3860


SEQ NO  71 U.A NO.  35404 UA NAME WHEELING WV              CSO AREA    6130. CSO POP    57946.
UA POP    60705. UA SIZE   20.9 70 SMSA POP   181954.
2000 SMSA POP   167900. NO.CSO PTS. 173# DAYS W/ RAIN  146.0 MEAN RAIN 38.95
 RW CLASS  4 FLOW  69430. % DRAINED 100.00
 RW TEMP 23.80 BOD    1.0 SS   20.0 PB 0.0167 HARD   35.0 ALK   10.0 PH 6.80
 COST FACTOR 1.0413 CRAT 0.3860
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URBANIZED AREA DATA BASE LISTING

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                                                              CSO AREA       0. CSO POP         0.
SEQ NO 314 U.A NO.  35405 UA NAME PARKERSBURG WV
UA POP    57821. UA SIZE   17.1 70 SMSA POP   148132.
2000 SMSA POP   220400. NO.CSO PTS.   0# DAYS W/ RAIN  143.0 MEAN RAIN 39.11
 RW CLASS  4 FLOW  69430. % DRAINED 100.00
 RW TEMP 23.80 BOD    0.5 SS   32.0 PB 0.0167 HARD   35.0 ALK   10.0 PH 7.00
 COST FACTOR 1.0413 CRAT 0.3860

                                                              CSO AREA       0. CSO POP         0.
SEQ NO 176 U.A NO.  55501 UA NAME APPLETON WI
UA POP   129532. UA SIZE   37.1 70 SMSA POP   276948.
2000 SMSA POP   351000. NO.CSO PTS.   0# DAYS W/ RAIN  121.0 MEAN RAIN 28.23
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.5 SS   20.0 PB 0.0167 HARD   85.0 ALK  100.0 PH 7.30
 COST FACTOR 1.0415 CRAT 0.3500

                                                              CSO AREA    3134. CSO POP     30100.
SEQ NO 177 U.A NO.  55502 UA NAME DULUTH METRO WI
UA POP    32713. UA SIZE   39.8 70 SMSA POP   265350.
2000 SMSA POP   249300. NO.CSO PTS.  28# DAYS W/ RAIN  135.0 MEAN RAIN 28.97
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 19.90 BOD    2.4 SS   32.0 PB 0.0167 HARD  100.0 ALK  100.0 PH 7.50
 COST FACTOR 1.2468 CRAT 0.3500

                                                              CSO AREA     918. CSO POP      9860.
SEQ NO 178 U.A NO.  55503 UA NAME GREEN BAY WI
UA POP   129105. UA SIZE   77.6 70 SMSA POP   158244.
2000 SMSA POP   196000. NO.CSO PTS.   0# DAYS W/ RAIN  121.0 MEAN RAIN 26.51
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 20.10 BOD    1.5 SS   20.0 PB 0.0167 HARD   85.0 ALK  100.0 PH 7.30
 COST FACTOR 1.0415 CRAT 0.3500

                                                              CSO AREA    1400. CSO POP     29724.
SEQ NO 179 U.A NO.  55504 UA NAME KENOSHA WI
UA POP    84262. UA SIZE   17.5 70 SMSA POP   117917.
2000 SMSA POP   140500. NO.CSO PTS.  41# DAYS W/ RAIN  114.0 MEAN RAIN 31.95
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 22.10 BOD    2.5 SS   80.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.60
 COST FACTOR 1.0415 CRAT 0.3500

                                                              CSO AREA       0. CSO POP         0.
SEQ NO 180 U.A NO.  55505 UA NAME LA CROSSE WI
UA POP    60231. UA SIZE   21.2 70 SMSA POP    80648.
2000 SMSA POP   100000. NO.CSO PTS.   0# DAYS W/ RAIN  112.0 MEAN RAIN 28.92
 RW CLASS  4 FLOW  25890. % DRAINED 100.00
 RW TEMP 21.60 BOD    3.0 SS   80.0 PB 0.0167 HARD  200.0 ALK  200.0 PH 7.80
 COST FACTOR 1.0415 CRAT 0.2350
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URBANIZED AREA DATA BASE LISTING

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SEQ NO 181 U.A NO.  55506 UA NAME MADISON WI                 CSC AREA       0. CSO POP         0.
UA POP   205457. UA SIZE   68.8 70 SMSA POP   290272.
2000 SMSA POP   505300. NO.CSO PTS.   0# DAYS W/ RAIN  115.0 MEAN RAIN 30.71
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 22.70 BOD    2.5 SS   80.0 PB 0.0167 HARD  200.0 ALK  150.0 PH 7.50
 COST FACTOR 1.0415 CMAT 0.2350


SEQ NO 182 U.A NO.  55507 UA NAME MILWAUKEE WI               CSC AREA   17776. CSO POP    370300.
UA POP  1252456. UA SIZE  456.5 70 SMSA POP  1403884.
2000 SMSA POP  1581100. NO.CSO PTS. 168# DAYS W/ RAIN  119.0 MEAN RAIN 27.57
 RW CLASS  6 FLOW    522. % DRAINED 100.00
 RW TEMP 22.70 BOD    2.0 SS   80.0 PB 0.0167 HARD  150.0 ALK  150.0 PH 7.50
 COST FACTOR 1.0415 CMAT 0.3500


SEQ NO 183 U.A NO.  55508 UA NAME OSHKOSH WI                 CSC AREA     210. CSO POP      4559.
UA POP    55480. UA SIZE   12.6 70 SMSA POP   276948.
2000 SMSA POP   351000. NO.CSO PTS.   8# DAYS W/ RAIN  121.0 MEAN RAIN 28.12
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 22.70 BOD    2.0 SS   80.0 PB 0.0167 HARD  150.0 ALK  150.0 PH 7.50
 COST FACTOR 1.0415 CMAT 0.3500


SEQ NO 184 U.A NO.  55509 UA NAME RACINE WI                  CSC AREA    1355. CSO POP     28770.
UA POP   117408. UA SIZE   28.1 70 SMSA POP   170828.
2000 SMSA POP   195000. NO.CSO PTS.  50# DAYS W/ RAIN  119.0 MEAN RAIN 31.95
 RW CLASS  8 FLOW      0. % DRAINED 100.00
 RW TEMP 22.70 BOD    2.0 SS   80.0 PB 0.0167 HARD  150.0 ALK  150.0 PH 7.50
 COST FACTOR 1.0415 CMAT 0.3500


SEQ NO 317 U.A NO.  27201 UA NAME CAGUAS PR                  CSC AREA       0. CSO POP         0.
UA POP    65844. UA SIZE    8.5 70 SMSA POP    95661.
2000 SMSA POP   151000. NO.CSO PTS.   0# DAYS W/ RAIN  150.0 MEAN RAIN 65.61
 RW CLASS  2 FLOW    216. % DRAINED 100.00
 RW TEMP 27.50 BOD    0.8 SS  922.0 PB 0.0    HARD   99.5 ALK   97.6 PH 7.20
 COST FACTOR 1.3223 CMAT 0.0


SEQ NO 318 U.A NO.  27202 UA NAME MAYAGUEZ PR                CSC AREA       0. CSO POP         0.
UA POP    69558. UA SIZE   14.3 70 SMSA POP    85857.
2000 SMSA POP   140000. NO.CSO PTS.   0# DAYS W/ RAIN  150.0 MEAN RAIN 76.12
 RW CLASS 15 FLOW      0. % DRAINED 100.00
 RW TEMP 29.50 BOD    3.6 SS    0.0 PB 0.0    HARD   65.8 ALK   72.0 PH 7.00
 COST FACTOR 1.3223 CMAT 0.0
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                    URBANIZED AREA DATA BASE LISTING


SEQ NO 319 U.A NO.  27203 UA NAME PONCE PR                CSC AREA       0. CSO POP         0.
UA POP   128233. UA SIZE   17.0 70 SMSA POP   158981.
2000 SMSA POP   260000. NO.CSO PTS.   0# DAYS W/ RAIN   99.0 MEAN RAIN 36.53
 RW CLASS  4 FLOW     16. % DRAINED  50.00
 RW TEMP 30.50 BOD    2.2 SS    0.0 PB 0.0    HARD  403.3 ALK  271.3 PH 7.90
 COST FACTOR 1.3223 CWAT 0.0


SEQ NO 320 U.A NO.  27204 UA NAME SAN JUAN PR             CSC AREA    1067. CSO POP    17800.
UA POP   820442. UA SIZE  102.5 70 SMSA POP  1185406.
2000 SMSA POP  1300000. NO.CSO PTS.   0# DAYS W/ RAIN  208.0 MEAN RAIN 64.21
 RW CLASS 10 FLOW      0. % DRAINED 100.00
 RW TEMP 31.50 BOD    3.7 SS   88.0 PB 0.0    HARD  141.7 ALK  143.3 PH 7.50
 COST FACTOR 1.3223 CWAT 0.0
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APPENDIX C

NONURBANIZED AREA CSO DATA BASE

Table C-1
Non-Urbanized Area Combined Sewer Data Base

State Name	Combined Sewer Area (acres)	Combined Sewer Population	Number of Systems	Number of CSO Points	Annual Number of Days with Rain	Annual Rainfall (inches)	Mean RW Flow (cfs)	Background BOD (mg/l)	Background SS (mg/l)	Construction Cost Factor	Natural Runoff Coefficient
Alabama	0.	--	--	--	--	--	--	--	--	--	--
Alaska	324.	5,410.	2	0	174	35.	0.	0.	173.	1.033000	0.530
Arizona	0.	--	--	--	--	--	--	--	--	--	--
Arkansas	0.	--	--	--	--	--	--	--	--	--	--
California	2,750.	25,000.	2	2	49	15.	280.	1.	10.	1.134399	0.459
Colorado	1,015.	17,000.	2	0	87	14.	0.	1.	80.	0.884300	0.077
Connecticut	5,221.	50,366.	7	33	125	43.	7,124.	1.	20.	1.091900	0.565
Delaware	1,515.	9,700.	4	23	117	44.	92.	1.	20.	1.181800	0.412
District of Columbia	0.	--	--	--	--	--	--	--	--	--	--
Florida	630.	4,370.	1	10	114	51.	0.	1.	20.	0.884300	0.306
Georgia	360.	3,820.	1	4	115	47.	6,677.	1.	20.	0.834700	0.306
Hawaii	0.	--	--	--	--	--	--	--	--	--	--
Idaho	9,306.	46,012.	14	24	90	11.	5,233.	2.	12.	1.033000	0.530
Illinois	77,878.	552,116.	91	223	113	35.	13,646.	3.	140.	1.160899	0.235
Indiana	78,788.	430,554.	93	286	121	38.	2,148.	3.	100.	1.104500	0.386
Iowa	17,422.	236,370.	14	38	104	31.	37,778.	3.	140.	0.835400	0.235
Kansas	400.	5,000.	1	3	91	33.	38,910.	2.	240.	1.000000	0.077
Kentucky	15,567.	241,521.	14	94	122	42.	140,491.	2.	46.	1.041499	0.386
Louisiana	0.	--	--	--	--	--	--	--	--	--	--
Maine	32,986.	257,976.	56	165	125	43.	5,564.	1.	20.	1.222600	0.565
Maryland	10,105.	53,886.	11	62	112	43.	12,941.	1.	20.	1.008300	0.391
Massachusetts	5,744.	220,607.	14	78	129	43.	5,463.	1.	20.	1.134899	0.565
Michigan	25,075.	240,673.	52	134	134	31.	3,649.	1.	30.	1.049600	0.350
Minnesota	4,369.	29,242.	15	10	116	26.	3,573.	3.	100.	1.041499	0.235
Mississippi	1,570.	19,100.	3	1	116	52.	0.	1.	20.	1.100900	0.327
Missouri	2,196.	28,791.	8	18	101	37.	38,762.	2.	140.	1.100900	0.257
Montana	7,723.	128,981.	11	0	99	14.	0.	2.	85.	0.884300	0.072
Nebraska	270.	7,900.	1	1	98	25.	5,660.	2.	240.	0.837100	0.072

Table C-1 (Continued)

State Name	Combined Sewer		Number of Systems	Number of CSO Points	Annual Number of Days with Rain	Annual Rainfall (inches)	Mean RW Flow (cfs)	Background		Construction Cost Factor	Natural Runoff Coefficient
	Area (acres)	Population						BOD (mg/l)	SS (mg/l)		
Nevada	0.	--	--	--	--	--	--	--	--	--	--
New Hampshire	3,203.	139,656.	21	112	124	42.	1,589.	1.	20.	1.122600	0.565
New Jersey	4,791.	446,767.	3	11	113	43.	16,306.	1.	20.	1.181800	0.412
New Mexico	0.	--	--	--	--	--	--	--	--	--	--
New York	21,155.	417,307.	28	163	148	37.	15,864.	1.	20.	1.233800	0.497
North Carolina	566.	8,900.	2	0	115	51.	1,333.	1.	40.	0.628100	0.306
North Dakota	843.	15,962.	7	4	106	19.	2,508.	3.	200.	1.041499	0.072
Ohio	121,403.	842,087.	73	475	142	37.	15,426.	2.	46.	1.041499	0.386
Oklahoma	0.	--	--	--	--	--	--	--	--	--	--
Oregon	9,755.	50,782.	21	130	152	39.	82,299.	1.	20.	1.033000	0.530
Pennsylvania	22,448.	620,951.	79	998	132	41.	4,426.	1.	20.	1.031300	0.391
Rhode Island	11,865.	197,000.	2	87	124	42.	297.	1.	20.	1.120899	0.565
South Carolina	0.	--	--	--	--	--	--	--	--	--	--
South Dakota	2,132.	35,599.	11	1	96	25.	0.	3.	240.	1.041499	0.072
Tennessee	6,580.	34,000.	1	0	120	45.	0.	2.	60.	0.828900	0.413
Texas	0.	--	--	--	--	--	--	--	--	--	--
Utah	284.	4,736.	2	0	87	15.	0.	1.	60.	0.884300	0.086
Vermont	11,187.	123,117.	28	161	148	33.	1,619.	1.	20.	1.122600	0.497
Virginia	2,672.	30,850.	7	19	115	43.	3,848.	1.	20.	1.008300	0.306
Washington	17,299.	88,007.	20	119	149	61.	6,495.	1.	20.	1.033000	0.530
West Virginia	34,137.	296,559.	33	246	147	41.	9,432.	1.	20.	1.041300	0.386
Wisconsin	6,128.	84,035.	8	53	120	29.	5,347.	3.	46.	1.041499	0.235
Wyoming	877.	14,645.	1	0	101	15.	0.	1.	226.	0.884300	0.072
American Samoa	0.	--	--	--	--	--	--	--	--	--	--
Guam	0.	--	--	--	--	--	--	--	--	--	--
Puerto Rico	0.	--	--	--	--	--	--	--	--	--	--
Trust Territories	0.	--	--	--	--	--	--	--	--	--	--
Virgin Islands	0.	--	--	--	--	--	--	--	--	--	--

APPENDIX D

FORTRAN LISTING OF NEEDS ESTIMATION COMPUTER PROGRAM

```
C NOTE I HAVE COMENTED OUT VT=,VT1=
C NOTE I HAVE COMMENTED OUT S25=,S26=
C
C   ********************************************************
C   *   NEEDS ESTIMATION PROGRAM FOR CATEGORIES V AND VI  *
C   ********************************************************
C
C   DEVELOPED BY:   CH2M HILL INC.
C                   7201 N.W. 11TH PLACE
C                   GAINESVILLE FLORIDA 32602
C
C            FOR:   FACILITIES REQUIREMENTS DIVISION
C                   U.S. ENVIRONMENTAL PROTECTION
C                   AGENCY
C                   WASHINGTON D.C.
C
C
C
C   PART I OF THIS PROGRAM COMPUTES COMBINED SEWER OVERFLOW
C   (CAT V) NEEDS AND URBAN STORMWATER RUNOFF (CAT VI) NEEDS
C   FOR PRESENT AND YEAR 2000 CONDITIONS FOR 320 URBANIZED
C   AREAS.  BOTH CAPITAL AND OPERATION & MAINTENANCE COSTS
C   ARE ESTIMATED
C
C
C
C   PART II OF THIS PROGRAM COMPUTES ADDITIONAL COMBINED SEWER
C   OVERFLOW (CAT V) NEEDS FOR COMBINED SEWER SYSTEMS LOCATED
C   OUTSIDE OF URBANIZED AREAS.
C
C
      DIMENSION EPAPOP(78),OBPOP(78),EPA1(78),OBP(78)
      INTEGER EPAPOP,OBPOP,TLFW5,TLFW6
      DATA EPAPOP/4140000,667000,0,4149000,2970000,26786000,0,
     1 3868000,3741000,841000,661000,1504900,7053000,0,1366000,
     2 1183000,12358000,5732000,3101000,2517000,4224000,4659000,
     3 1222000,5583000,6614000,10314000,4505000,2740000,5225000,
     4 802000,1734000,1141000,1306000,8747000,1436000,18922000,
     5 7419000,690000,12031000,3396000,3209000,12365000,0,1033000,
     6 3700000,730000,5573000,18069000,1688000,607000,6755000,0,
     7 4417000,2003000,5553000,484000,0,0,0,40000,0,0,0,0,0,275000,
     8 0,0,0,0,0,4700000,0,0,205000,0,0,116000/
      DATA OBPOP/4284300,438000,0,3065500,2380400,27049400,0,
     1 3134000,4030000,779100,750000,12713900,6458100,0,1085200,
     2 755400,13877000,6837000,3053500,2322200,4233500,4021200,
     3 1002900,5947400,7456700,11342500,4900700,2496400,5717000,
     4 656400,1609800,881500,989400,9693900,1180400,22438400,
     5 6972900,545200,13382200,3144700,2680100,13994300,0,1191700,
     6 3319400,637000,5625200,14632600,1412100,550200,6782300,0,
     7 3992100,1845100,5012900,334000,0,0,0,40000,0,0,0,0,0,275000,
     8 0,0,0,0,0,4688827,0,0,205000,0,0,11600/
      REAL NEWSWA ,LEN,NSFYR,NDR
      DIMENSION UANM(6)
      INTEGER SEQ,UANC
      REAL LCSO,LSWR,IWWTP,LUSF
      REAL LRATB,LRATS
1000  FORMAT(2I8,6A4,5F8.0/F8.0,I8,2F8.0,I8,5F8.0/6F8.0)
1004  FORMAT(1X,5('*'),'SSPOP FOR SEQ NO.',I6,'IS LT 0.0')
1005  FORMAT(1X,5('*'),'CSPOP LT 1.0 AND CSAREA=0 FOR SEQ NO.',I6)
1006  FORMAT(1X,5('*'),'SSAREA LT 0 FOR SEQ NO.',I6)
1007  FORMAT(I1,I3,I6,6A4,F8.0,2F9.0,F6.1,2F9.0,I3,F6.1,F5.2,I2,F7.0,F6
     1.2,                                                               00006300
     1F5.2,2F6.1,F6.4,2F6.1,F4.2,2F6.4,2I1,12F14.0,F13.0,2F5.2,         00006400
     1 2I1,2F6.3,2I1,4F6.3,3F6.4,4F6.3,2I2,2F8.1,2F9.0)                 00006410
C                                                                       00006500
C THIS PROGRAM WRITES 2 RECORDS                                         00006600
C -1ST- PRESENT CONDITIONS AND COSTS                                    00006700
C -2ND- YEAR 2000 CONDITIONS AND COSTS                                  00006800
C                                                                       00006900
C***********************************************                        00007000
C                                                                       00007100
C INITIALIZE ALL VARIABLES                                              00007200
C                                                                       00007300
       DO 10  I=1,78                                                    00007400
       EPA1(I)=EPAPOP(I)                                                00007500
       OBP(I)=OBPOP(I)                                                  00007600
10     CONTINUE                                                         00007700
       K=1                                                              00007800
       KMAX=320                                                         00007900
C***************************************************                    00008000
C                                                                       00008100
C READ UA DATA  SEQUENCE =K                                             00008200
C                                                                       00008300
50    CONTINUE                                                          00008400
C                                                                       00008500
C READ URBANIZED AREA DATA                                              00008600
C                                                                       00008700
       READ(5,1000,END=99) SEQ,UANO,UANM,CSAREA,CSPOP,UAPOP,UASZ,       00008800
     1 POP70,POP00,NCSC,NDR,RAIN,ICLASS,QUSF,PD,T,BOD,SS,PB,HARD,       00008900
     1 ALK,PH,CF,CNAT                                                   00009000
       PD=PD/100.0                                                      00009100
C  J=1  PRESENT CONDITIONS                                              00009200
C  J=2  YR 2000 CONDITIONS                                              00009300
C                                                                       00009400
       J=1                                                              00009500
C*****************************************************                  00009600
C                                                                       00009700
C COMPUTE UA CHARACTERISTICS-PRESENT CONDITIONS                         00009800
C                                                                       00009900
C                                                                       00010000
C   ******************************************                          00010100
C   *   COMPUTE URBANIZED AREA CHARACTERISTICS   *                      00010200
C   ******************************************                          00010300
C                                                                       00010400
C                                                                       00010500
C STORMWATER AREA                                                       00010600
C                                                                       00010700
       SSAREA=UASZ*640.0-CSAREA                                         00010800
       IF(SSAREA.LT.0.0)WRITE(6,1006) SEQ                               00010900
       IF(SSAREA.LT.0.0)GOTO 50                                         00011000
C                                                                       00011100
C   POPULATION DENSITY - COMBINED SEWER                                 00011200
C                                                                       00011300
100    CONTINUE                                                         00011400
       IF(CSPOP.LT.1.0.AND.CSAREA.GT.0.0)WRITE(6,1005) SEQ              00011500
       IF(CSPOP.LT.1.0.AND.CSAREA.GT.0.0)GOTO 50                        00011600
       IF(CSAREA.GT.0.5)GOTO 150                                        00011700
       PDCS=0.0                                                         00011800
       CSPOP=0.0                                                        00011900
       CSIMP=0.0                                                        00012000
       GOTO 200                                                         00012100
150     CONTINUE                                                        00012200
```

```
      PDCS=CSPOP/CSAREA
200   CONTINUE
C
C   POPULATION DENSITY - STORMWATER AREA
C
      SSPOP=UAPOP-CSPOP
205   CONTINUE
      IF(SSPOP.LT.0.0)WRITE(6,1004)SEQ
      IF(SSPOP.LT.0.0)GO TO 50
      PDSS=SSPOP/SSAREA
C
C   IMPERVIOUSNESS - COMBINED SEWER AREA
C
      IF(CSAREA.LE.0.5)GOTO 210
      X1=ALOG10(PDCS)
      X2=0.573-(0.0391*X1)
      CSIMP=9.6*(PDCS**X2)
      CSIMP=CSIMP/100.0
210   CONTINUE
C
C   IMPERVIOUSNESS - STORMWATER AREA
C
      X01=ALOG10(PDSS)
      X02=0.573-(0.0391*X01)
      SSIMP=9.6*(PDSS**X02)
      SSIMP=SSIMP/100.0
C
C   RUNOFF COEFF - COMBINED SEWER AREA
C
      ROCS=0.90*CSIMP+CNAT*(1.0-CSIMP)
C
C   RUNOFF COEFF - STORMWATER AREA
C
      ROSS=0.90*SSIMP+CNAT*(1.0-SSIMP)
C
C   ******************************************
C   *   MILES OF STREET IN URBANIZED AREA    *
C   ******************************************
C
      UAPOP=UAPOP/1000.0
      IF(UAPOP.GE.100.0)GOTO 250
C FOR UAPOP LT 100,000
C
      TOTMIL=45.0+(UAPOP-10.0)*1.9444
      GOTO 300
250   CONTINUE
C  FOR UAPOP GT 100,000
C
      TOTMIL=220.0+(UAPOP-100.0)*1.9778
300   CONTINUE
      UAPOP=UAPOP*1000.0
C
C   MILES - COMBINED SEWER AREA
C
      SMCS=TOTMIL*CSPOP/UAPOP
C
C   MILES - STORMWATER AREA
C
      SMSS=TOTMIL*SSPOP/UAPOP
C
C   ******************************************
```

```
C   *   COMPUTE ANNUAL POLLUTANT LOADS #/YR *
C   ***************************************
C
C ANNUAL POLLUTANT LOAD - COMBINED SEWER AREA
C
      TE1=0.142+0.218*(PDCS**0.54)
      BODC=RAIN*(1.92*TE1+1.89)
      CSOBOD=BODC*CSAREA*PD
C
      SSC=RAIN*(39.24*TE1+25.94)
      CSOSS=SSC*CSAREA*PD
      PBC=RAIN*(0.0126*TE1+0.0124)
      CSOPB=PBC*CSAREA*PD
C
C
C ANNUAL POLLUTANT LOAD- STORMWATER AREA
C
      TE2=0.142+0.218*(PDSS**0.54)
      BODS=RAIN*(0.467*TE2+0.457)
      SWRBOD=BODS*SSAREA*PD
      SSS=RAIN*(9.52*TE2+6.29)
      SWRSS=SSS*SSAREA*PD
      PBS=RAIN*(0.0126*TE2+0.0124)
      SWRPB=PBS*SSAREA*PD
C
C
C ANNUAL LOAD - WWTP EFFLUENT
C
      WWBOD=9.12*UAPOP*PD
      WWSS=9.12*UAPOP*PD
      WWPB=0.01210*UAPOP*PD
C
C
C ANNUAL LOAD - BACKGROUND UPSTREAM FLOW
C
      UFBOD=BOD*QUSF*1967.8
      UFSS=SS*QUSF*1967.8
      UFPB=PB*QUSF*1967.8
C
C
C   ***************************************
C   *  COMPUTE TOTAL WATER YIELD (CFS)    *
C   ***************************************
C
C COMBINED SEWER OVERFLOW
      CSRUN=RUN(RAIN,ROCS,CSAREA)
C STORMWATER RUNOFF
      SSRUN=RUN(RAIN,ROSS,SSAREA)
C WWTP AT (100 GPCD  -CFS)
      WWTP=1.547E-4*UAPOP
C TOTAL FLOW ***************
      QT=(CSRUN+SSRUN+WWTP)*PD+QUSF
C
C  AR5 - ANNUAL RUNOFF CSO IN INCHES
C  AR6 - ANNUAL RUNOFF SWR IN INCHES
C
      AR5=RAIN*ROCS
      AR6=RAIN*ROSS
C*****************************************************
C
C  COMPUTE COSTS FOR AESTHETICS LEVEL
```

```
C     A) CAPITAL--ALC
C     B) O & M--ALCM
C
C    ******************************
C    *   AESTHETICS OBJECTIVE     *
C    ******************************
C
C
C    *****************
C    * CAT V (CSO)   *
C    *****************
      IF(CSAREA.LT.0.5)GOTO 340
C
C    CAPITAL COST STREET SWEEPING
C
      CSW=SMCS*2.0*7.25*365*0.25
C
C    O&M COST STREET SWEEPING
C
      CMSW=SMCS*2.0*9.45*365*0.25
C
C    CAPITAL COST SEWER FLUSHING
C
      CSF=CSAREA*6105.0*0.13
C
C    O&M COST SEWER FLUSHING
C
      OMSF=CSAREA*724.0*0.13
C
C    SUM COSTS FOR AESTHETICS LEVEL
C
      ALC5=CSW+CSF
      ALOM5=CMSW+OMSF
340   CONTINUE
      IF(CSAREA.LE.0.5)ALC5=0.0
      IF(CSAREA.LE.0.5)ALOM5=0.0
C

C
C*********************************************
C   *     AESTHETICS OBJECTIVE--CAT VI (SWR)    *
C*********************************************
C
C    *********************************************
C    *   COMPUTE CAPITAL COST OF STREETSWEEPING    *
C    *********************************************
C
C PRESENT VALUE OF STREET SWEEPING
      ALC6=SMSS*7.25*365*0.30
C  COMPUTE O & M  COST OF STREETSWEEPING
C
      CMSS=SMSS*9.45*365*0.30
C   COMPUTE ANNUAL COST OF EROSION CONTROL
C   SUM ANNUAL COSTS
      OMEC=SSAREA*0.04*464.0
      ALOM6=CMSS+OMEC
C  COMPUTE CAPITAL COST OF DETENTION BASINS IN NEW
C  NEW AREAS (J=2) ONLY
      IF (J.NE.2)GOTO 350
      NEWSWA=SSAREA-PSSA
      IF(NEWSWA.LT.0.0)NEWSWA=0.0
      IF(NEWSWA.LT.0.5)GOTO 350
      NTP2=(NEWSWA/1000.0)**0.435+0.5
      IF(NTP2.LT.1)NTP2=1
      DATP=NEWSWA/NTP2
      AR=ROSS*RAIN
C STORAGE CAPACITY (INCHES)
      S=0.1048*(AR**0.372)
C STORAGE VOLUME (MG)
      V=S*DATP*0.02715
      CCS=30300.0*(V**0.783)
      CCS=NTP2*CCS
      ALC6=ALC6+CCS
C   *  COMPUTE O & M COST OF DETENTION BASINS IN
C   *  NEW AREAS
C
      OMCS=2670.0*(V**0.509)
      OMCS=OMCS+618.0*(V**0.405)
      OMCS=OMCS+15.8*(V**0.493)
      ALOM6=ALOM6+OMCS
350   CONTINUE
C
C   ***********************************************
C   *   COMPUTE REMOVAL REQUIREMENTS FOR F & W   *
C   ***********************************************
C
C   *************************
C   *   SUSPENDED SOLIDS   *
C   *************************
C
      TSS=CSOSS+SWRSS
      QSS=CSRUN+SSRUN
C IN CFS
C # PER YEAR
      QSS=62.4*24.0*3600.0*365.0*QSS
C  CONC  (MG/L)
      CONSS=TSS*1.0E+6/QSS
      SSMAX=SS
      IF(SSMAX.LT.25.0)SSMAX=25.0
      IF(CONSS.LE.SSMAX)SSREM=0.0
      IF(CONSS.LE.SSMAX)GOTO 400
      SSREM=(CONSS-SSMAX)/CONSS
      SSREM=100*SSREM
C ADDED 12-4-78
      IF(SSREM.LT.40.0)SSREM=40.0
C  %
400   CONTINUE
C ************
C   *   BOD   *
C ************
C
C FROM APL
C # PER YEAR
      LCSO=CSOBOD
      LSWR=SWRBOD
      LWWTP=WWBOD
      LUSF=UFBOD
C SKIP LAKES,OCEANS,PONDS
      IF(ICLASS.EQ.7.OR.ICLASS.EQ.8.OR.ICLASS.EQ.15)BODREM=80.0
      IF(ICLASS.EQ.7.OR.ICLASS.EQ.8.OR.ICLASS.EQ.15)GOTO 550
C  TIDAL ESTUARY
```

```
      IF(ICLASS.GE.6) GOTO 450
      IF(QUSF.LE.0.5) RWK=10.2
      IF(QUSF.LE.0.5) GOTO 500
      RWK=153.6*QUSF**(-0.5882)
      IF(RWK.GT.10.2) RWK=10.2
      IF(RWK.LT.0.176) RWK=0.176
      GOTO 500
450   CONTINUE
      CALL RWK2(ICLASS,RWK)
500   CONTINUE
C NUMBER OF STORMS PER YEAR
      NSPYR=1.0022*NDR-2.58
C  DURATION RUNOFF CS
      D1=0.6*9.94*NSPYR
      D1=D1/8760.0
C   DURATION RUNOFF SWR
      D2=0.5*9.94*NSPYR
      D2=D2/8760.0
C WET WEATHER
      QWW=QUSF+WWTP+CSRUN/D1+SSRUN/D2
C  DRY WEATHER
      QDW=QUSF+WWTP
      CSOQP=(LCSO*0.40)/(D1*8760.0)
      SWRQP=(LSWR*0.16)/(D2*8760.0)
      USFQP=(LUSF*0.16)/8760.0
      WWTPQP=(LWWTP*0.23)/8760.0
      WWQP=(CSOQP+SWRQP+USFQP+WWTPQP)/(QWW*RWK)
      DWQP=(USFQP+WWTPQP)/(QDW*RWK)
      DOSAT=14.652-0.410222*T+0.00799*(T**2)-0.00007777*(T**3)
      DWDO=DOSAT-1.66
      VT=0.0
      VT1=0.0
C
C   COMPUTE TOTAL VIOLATIONS FOR UA
C
      VT=1013.0+864.0*DWQP+256.0*WWQP-204.0*DWDO
C     VT=VT-353.0
      IF(VT.LE.4.0) BODREM=0.0
      IF(VT.LE.4.0) GOTO 550
C  W/C NPS
      WWQP1=(USFQP+WWTPQP)/(QWW*RWK)
      VT1=1013.0+864.0*DWQP+256.0*WWQP1-204.0*DWDO
C     VT1=VT1-353.0
C VT1 GT 4.0 MEANS CANT REACH CRITERIA
      IF(VT1.GT.4.0) BODREM=90.0
      IF(VT1.GT.4.0) GOTO 550
C   CAN MEET CRITERIA
      WWQP2=(204.0*DWDO-864.0*DWQP-1009.0)/256.0
      X=(WWQP-WWQP2)/(WWQP-WWQP1)
      BODREM=100.0*X
      IF(BODREM.GT.95.0) BODREM=95.0
550   CONTINUE
      IF(BODREM.LT.40.0) BODREM=40.0
C
C   ************************************************************
C   *   COMPUTE REMOVAL OBTAINED FROM AESTHETICS OBJECTIVE     *
C   ************************************************************
C
C  ***** PRESENT CONDITIONS    (J=1)
      IF(J.NE.1) GOTO 650
C   AESTHETICS LEVEL BCD & SS  REMOVAL
```

```
      ALBODR=(40.0*LCSO+22.0*LSWR)/(LCSO+LSWR)
      ALSSR=(40.0*CSOSS+22.0*SWRSS)/(CSOSS+SWRSS)
  600 CONTINUE
      IF(ALBODR.LT.BODREM.OR.ALSSR.LT.SSREM)GOTO 750
      FWLC5=ALC5
      FWLCM5=ALCM5
      FWLC6=ALC6
      FWLCM6=ALCM6
      GOTO 700
  650 CONTINUE
C   FUTURE CONDITIONS (J=2)
C EFFICIENCY SS & BOD REMOVAL AES OBJECTIVES
      EFFSS=(43.0*NEWSWA+22*PSSA)/SSAREA
      EFFBOD=(40.0*NEWSWA+22*PSSA)/SSAREA
      ALBODR=(40.0*LCSO+EFFBOD*LSWR)/(LCSO+LSWR)
      ALSSR=(40.0*CSOSS+EFFSS*SWRSS)/(CSOSS+SWRSS)
      GOTO 600
C
C   IF EXTRA COSTS ARE NOT REQUIRED TO
C   MEET THE F & W OBJECTIVE SET TREATMENT LEVEL = 2 AND
C   DETERMINE VALUES FOR SSAV5,SSAV6,TSAV5,TSAV6
C   THEN PROCEED TO THE RECREATION OBJECTIVE
CC
  700 CONTINUE
      ILEV5=2
      ILEV6=2
      NTP5=0.0
      IF(CSAREA.GT.0.0)
     1 NTP5=(CSAREA/1000.0)**0.435+0.5
      NTP6=(SSAREA/1000.0)**0.435+0.5
      DA5=0.0
      IF(CSAREA.GT.0.0.AND.NTP5.LT.1) NTP5=1
      IF(CSAREA.GT.0.0)
     1 DA5=CSAREA/NTP5
      DA6=SSAREA/NTP6
      IEPA=UANO/10000
      IT1=UANO-IEPA*10000
      IST=IT1/100
      CALL RAINRG(IST,IRG)
      CALL ISOPAR(IRG,B,H,D,F)
      T15=(AR5*95)/876000.0
      T16=(AR6*95)/876000.0
      X56=B*EXP(H*95)
      Y56=D*EXP(-1.0*F*95)
      IF(CSAREA.LE.0.0) TSAV5=0.0
      IF(CSAREA.LE.0.5) SSAV5=0.0
      IF(CSAREA.GT.0.0)
     1 CALL STOPT(5,ILEV5,DA5,T15,X56,Y56,TSAV5,SSAV5)
      CALL STOPT(6,ILEV6,DA6,T16,X56,Y56,TSAV6,SSAV6)
      GOTO 1350
C**************************************************************
  750 CONTINUE
C DETERMINE CONTROL LEVEL REQ BY CATEGORY AND OPTIMUM MIX OF
C STRUCTURAL AND NONSTRUCTURAL CONTROLS BY CATEGORY, AND
C COSTS OF MANAGEMENT PRACTICES (MP'S)
C
C
C
C   ***********************************************
C   *   DETERMINE OPTIMUM MIX OF POLLUTANT REMOVAL   *
C   *   BY WATERSHED                                  *
```

```
C   ***************************************************
C
C  RRB5 - BOD REMOVAL COMBINED
C  RRS5 - SS
C  RRB6 - BOD         SEPARATE
C  RRS6 - SS
C
      IF(CSAREA.NE.0.0)GOTO 800
      RRB5=0.0
      RRS5=0.0
      RRB6=BODREM
      RRS6=SSREM
      GOTO 850
800   CONTINUE
C THIS IS CASE FOR CSAREA NOT = 0.0
C  RATIOS
      ARAT=CSAREA/(CSAREA+SSAREA)
      LRATB=(LCSO/CSAREA)/(LSWR/SSAREA)
      LRATS=(CSOSS/CSAREA)/(SWRSS/SSAREA)
C
C   A)   REMOVALS BY WATERSHED FOR BOD
C
C
      IF(BODREM.LT.0.5)RRB5=0.0
      IF(BODREM.LT.0.5)RRB6=0.0
      IF(BODREM.LT.0.5)GOTO 810
      RRB6=0.926*BODREM-2.696*LRATB+111.92*ARAT
      IF(RRB6.LT.0.0)RRB6=0.0
      IF(RRB6.GT.95.0)RRB6=95.0
      BODR6=(RRB6/100.0)*SWRBOD
      BODR5=(CSOBOD+SWRBOD)*(BODREM/100.0)-BODR6
      RRB5=(BODR5/CSOBOD)*100.0
      IF(RRB5.GT.95.0)RRB5=95.0
      IF(RRB5.LT.95.0)GOTO 810
      BODR5=0.95*CSOBOD
      BODR6=(CSOBOD+SWRBOD)*(BODREM/100.0)-BODR5
      RRB6=(BODR6/SWRBOD)*100.0
      IF(RRB6.GT.95.0)RRB6=95.0
C
C   B)   REMOVALS BY WATERSHED FOR SS
C
810   CONTINUE
      IF(SSREM.LT.0.5)RRS5=0.0
      IF(SSREM.LT.0.5)RRS6=0.0
      IF(SSREM.LT.0.5)GOTO 850
      RRS6=0.926*SSREM-2.696*LRATS+111.92*ARAT
      IF(RRS6.LT.0.0)RRS6=0.0
      IF(RRS6.GT.95.0)RRS6=95.0
      SSR6=(RRS6/100.0)*SWRSS
      SSR5=(CSOSS+SWRSS)*(SSREM/100.0)-SSR6
      RRS5=(SSR5/CSOSS)*100.0
      IF(RRS5.GT.95.0)RRS5=95.0
      IF(RRS5.LT.95.0)GOTO 850
      SSR5=0.95*CSOSS
      SSR6=(CSOSS+SWRSS)*(SSREM/100.0)-SSR5
      RRS6=(SSR6/SWRSS)*100.0
      IF(RRS6.GT.95.0)RRS6=95.0
850   CONTINUE
C
C   *   DETERMINE LEVEL OF EFFORT FOR MP (MANAGEMENT PRACTICE )
C   *   BY WATERSHED
```

```
C
C
C   XSWB5 - LEVEL OF EFFORT STREETSWEEPING BOD,CSO
C   XSWS5 -                                SS
C   XSWB6 -                                BOD,SWR
C   XSWS6 -                                SS
C   XSFB5 -                SEWER FLUSHING BOD,CSO
C   XSFS5                                   SS
C
      CALL SSCW(RRB5,XSWB5)
      CALL SSCW(RRS5,XSWS5)
      CALL SSSW(RRB6,XSWB6)
      CALL SSSW(RRS6,XSWS6)
      CALL SFCS(RRB5,XSFB5)
      CALL SFCS(RRS5,XSFS5)
C
C  *   DETERMINE COSTS OF MPS BY POLLUTANT BY WATERSHED
C
C     SW  - STREETSWEEPING
C     SF  - SEWER FLUSHING
C
C   CSWB5 - CAPITAL COST SW BOD,CSO
C   CMSWB5 - O&M
C   CSWS5  - CAPITAL COST SW SS,CSO
C   CMSWS5 - O&M
C   CSWB6  - CAPITAL          BOD,SWR
C   CMSWB6 - O&M
C   CSWS6  - CAPITAL          SS
C   CMSWS6 - O & M
C   CSFB5  - CAPITAL       SF BOD,CSO
C   CMSFB5 - O&M
C   CSFS5  - CAPITAL          SS
C   CMSFS5 - O&M
C
C
C   A)   CAPITAL COST OF STREET SWEEPING SWR
C
      CSWB6=SMSS*7.25*365*XSWB6
      CSWS6=SMSS*7.25*365*XSWS6
C
C   B)   O&M COST OF STREETSWEEPING  SWR
C
      CMSWB6=SMSS*9.45*365*XSWB6
      CMSWS6=SMSS*9.45*365*XSWS6
C
C   C)   CAPITAL COST OF STREETSWEEPING  CSO
C
      CSWB5=SMCS*2.0*7.25*365*XSWB5
      CSWS5=SMCS*2.0*7.25*365*XSWS5
C
C   D)   O&M COST OF STREETSWEEPING  CSO
C
      CMSWB5=SMCS*2.0*9.45*365*XSWB5
      CMSWS5=SMCS*2.0*9.45*365*XSWS5
C
C   E)   CAPITAL COST OF SEWER FLUSHING  CSO
C
      CSFB5=CSAREA*6105.0*XSFB5
      CSFS5=CSAREA*6105.0*XSFS5
C
C   F)   O&M COST OF SEWER FLUSHING  CSO
```

```
C
      CMSFB5=CSAREA*724.0*XSFB5
      CMSFS5=CSAREA*724.0*XSFS5
C
C   *   SUM COST BY POLLUTANT & WATERSHED
C
C  CMPB5 - CAPITAL MP  BOD CSO
C  CMPS5 -             SS
C  CMMPB5- O&M         BOD
C  CMMPS5              SS
C  CMPB6 - CAPITAL MP  BOD  SWR
C  CMPS6 -             SS
C  CMMPB6- O&M         BOD  SWR
C CMMPS6  -             SS
C
      CMPB5=CSWB5+CSFB5
      CMPS5=CSWS5+CSFS5
      CMMPB5=CMSWB5+OMSFB5
      CMMPS5=OMSWS5+OMSFS5
      CMPB6=CSWB6
      CMPS6=CSWS6
      CMMPB6=CMSWB6
      CMMPS6=CMSWS6
C   *   DETERMINE POLLUTANT REMOVALS FROM MP-S
C
C   TRANSFORM XSW TO YSW  AND XSF TO YSF
      YSWB5=TSW(XSWB5)
      YSWS5=TSW(XSWS5)
      YSWS6=TSW(XSWS6)
      YSWB6=TSW(XSWB6)
      YSFB5=TSF(XSFB5)
      YSFS5=TSF(XSFS5)
C
C   B)   TRANSFORM YSW TO FRSW
C
      FRSWB5=TFSW(0.24,PDCS,YSWB5)
      FRSWS5=TFSW(0.24,PDCS,YSWS5)
      FRSWB6=TFSW(0.50,PDSS,YSWB6)
      FRSWS6=TFSW(0.50,PDSS,YSWS6)
C
C   C)   TRANSFORM YSF TO FRSF
C
      FRSFB5=0.536*YSFB5
      FRSFS5=0.536*YSFS5
C
C   *   DETERMINE REMOVAL REQUIREMENTS FOR
C   *   STORAGE/TREATMENT SYSTEMS
C
C
C   STB5X - S/T REMOVAL BOD  CSO
C   STS5X -             SS
C   STB6X -             BOD  SWR
C   STS6X -             SS
C
C
      TE1=RRB5-(FRSWB5+FRSFB5)*100.0
      TE2=100.0-100.0*(FRSWB5+FRSFB5)
      STB5X=TE1/TE2
      STB5X=STB5X*100.0
      IF(STB5X.LE.1.0)STB5X=0.0
      TE1=RRS5-(FRSWS5+FRSFS5)*100.0
      TE2=100.0-100.0*(FRSWS5+FRSFS5)
      STS5X=TE1/TE2
      STS5X=STS5X*100.0
      IF(STS5X.LE.1.0)STS5X=0.0
C
      TE1=RRB6-(FRSWB6*100.0)
      TE2=100.0-100.0*FRSWB6
      STB6X=TE1/TE2
      STB6X=STB6X*100.0
      IF(STB6X.LE.1.0)STB6X=0.0
C
      TE1=RRS6-FRSWS6*100.0
      TE2=100.0-100.0*FRSWS6
      STS6X=TE1/TE2
      STS6X=STS6X*100.0
      IF(STS6X.LE.1.0)STS6X=0.0
C
C

C
C   *   DETERMINE TREATMENT LEVEL REMOVAL EFFICIENCY AND
C   *   CAPTURE REQUIRED
C
      CALL LEVBO6(STB6X,ILEV6B)
      CALL LEVBO5(STB5X,ILEV5B)
      CALL LEVSS6(STS6X,ILEV6S)
      CALL LEVSS5(STS5X,ILEV5S)
      EB6=REE(ILEV6B)
      EB5=REE(ILEV5B)
      ES6=RES(ILEV6S)
      ES5=RES(ILEV5S)
C
C   COMPUTE CAPTURE REQUIRED
C
      C5B=STB5X/EB5
      C6B=STB6X/EB6
      C5S=STS5X/ES5
      C6S=STS6X/ES6
C
C   *   COMPUTE OPTIMUM STORAGE/TREATMENT BY POLLUTANT   *
C   * AND WATERSHED
C
C   **************************************************
C   *   DETERMINE NUMBER OF TREATMENT PLANTS (NPT),   *
C   *   STORAGE VOLUME (V), TREATMENT RATE (T), AND   *
C   *   COSTS FOR STORAGE TREATMENT SYSTEMS            *
C   **************************************************
C
C     ITYPE=5   FOR CSC
C     ITYPE=6   FOR SWR
C
C
C   A) NUMBER OF TREATMENT PLANTS & DRAINAGE AREA
C
      IF(CSAREA.GT.0.0)GOTO 851
      NTP5=0.0
      DA5=0.0
      GOTO 852
851   CONTINUE
      NTP5=(CSAREA/1000.0)**0.435+0.5
      IF(NTP5.LT.1)NTP5=1
      DA5=CSAREA/NTP5
852   CONTINUE
      NTP6=(SSAREA/1000.0)**0.435+0.5
      IF(NTP6.LT.1)NTP6=1
      DA6=SSAREA/NTP6
C
C
C      ILEV5B = LEVL REQ BOD  REM  CSO AREA
C     ILEV6B = LEVL REQ BOD  REM  SWR AREA
C     ILEV5S = LEVL REQ SS   REM  CSO AREA
C    ILEV6S = LEVL REQ SS   REM  SWR AREA
C
C     C5B  = CAPTURE REQ BOD REM CSO AREA
C     C6B  =  "      REQ BOD REM SWR AREA
C     C5S  =             SS      CSO
C     C6S  =             SS      SWR
C
C    B) COMPUTE T15B,T15S,T16B,T16S
C
C    T15B = T1  CSO, BOD
C    T16B = T1  SWR, BOD
C    T15S = T1  CSO  SS
C    T16S = T1  SWR  SS
C
C    AR5 = ANNUAL RUNOFF CSO
C    AR6 = ANNUAL RUNOFF SWR
C
       T15B=(AR5*C5B)/876000.0
       T16B=(AR6*C6B)/876000.0
       T15S=(AR5*C5S)/876000.0
       T16S=(AR6*C6S)/876000.0
C
C    C)  COMPUTE X5B,X6B,X5S,X6S
C
       IEPA=UANO/10000
       IT1=UANO-IEPA*10000
       IST=IT1/100
       CALL RAINRG(IST,IRG)
       CALL ISOPAR(IRG,B,H,D,F)
       X5B=B*EXP(H*C5B)
       X6B=B*EXP(H*C6B)
       X5S=B*EXP(H*C5S)
       X6S=B*EXP(H*C6S)
C
C    D) COMPUTE Y5B,Y6B,Y5S,Y6S
C
       Y5B=D*EXP(-1.0*F*C5B)
       Y6B=D*EXP(-1.0*F*C6B)
       Y5S=D*EXP(-1.0*F*C5S)
       Y6S=D*EXP(-1.0*F*C6S)
C
C    E) FIND OPTIMUM STORAGE/TREATMENT COMBINATION FOR
C        COMBINED SEWER WATERSHED BOD REMOVAL
C
       IF(C5B.EQ.0.0)GOTO 853
       CALL STOPT(5,ILEV5B,DA5,T15B,X5B,Y5B,T5B,S5B)
C
C    F) FIND OPTIMUM STORAGE/TREATMENT COMBINATION FOR
C       STORMWATER BOD REMOVAL
C
```

```
853    IF(C6B.EQ.0.0)GOTO 854
       CALL STOPT (6,ILEV6B,DA6,T16B,X6B,Y6B,T6B,S6B)
C
C   G) FIND OPTIMUM STORAGE/TREATMENT COMBINATION FOR
CC      COMBINED SEWER WATERSHED SS REMOVAL
C
854    IF(C5S.EQ.0.0)GOTO 855
       CALL STOPT (5,ILEV5S,DA5,T15S,X5S,Y5S,T5S,S5S)
C
C   H) FIND OPTIMUM STORAGE/TREATMENT COMBINATION FOR
C      STORMWATER WATERSHED SS REMOVAL
C
855    IF(C6S.EQ.0.0)GOTO 856
       CALL STOPT (6,ILEV6S,DA6,T16S,X6S,Y6S,T6S,S6S)
C
856    CONTINUE
       IF(C5B.GT.0.0)GOTO 857
       T5B=0.0
       S5B=0.0
857    CONTINUE
       IF(C6B.GT.0.0)GOTO 858
       T6B=0.0
       S6B=0.0
858    CONTINUE
       IF(C5S.GT.0.0)GOTO 859
       T5S=0.0
       S5S=0.0
859    CONTINUE
       IF(C6S.GT.0.0)GOTO 860
       T6S=0.0
       S6S=0.0
860    CONTINUE
C*****************************************************************
C
C COMPUTE COSTS FOR STORAGE-TREATMENT SYSTEMS FOR F&W LEVEL BY CATEGORY
C   A) CAPITAL--FWLC
C   B) O&M    --FWLOM
C
C
C   **************************************************
C   *   COMPUTE CAPITAL AND O&M COSTS FOR STORAGE   *
C   *   TREATMENT SYSTEMS                            *
C   **************************************************
C
C
C   A)   COMPUTE COSTS FOR BOD REMOVAL FROM COMBINED SEWER
C        WATERSHED
C
       IF(T5B.GT.0.0.AND.S5B.GT.0.0)GOTO 862
       CC5B=0.0
       OM5B=0.0
       GOTO 864
862    CONTINUE
       Q5B=0.6518*T5B*DA5
       V5B=0.02715*S5B*DA5

       CALL CCL(ILEV5B,Q5B,CCT5B)
       CALL CMI(ILEV5B,Q5B,OMT5B)
       C1=CCDIS(Q5B)
       CM1=CMDIS(Q5B)
       CCT5B=CCT5B+C1
```

```
      CMT5B=CMT5B+OM1
      CCS5B=CCCS(V5B)
      CMS5B=OMS(V5B)
      CC5B=(CCT5B+CCS5B)*NTP5
      CM5B=(CMT5B+OMS5B)*NTP5
C
C   E)   COMPUTE COSTS FOR BOD REMOVAL FROM STORMWATER WATERSHED
C
  864 CONTINUE
      IF(T6B.GT.0.0.AND.S6B.GT.0.0) GOTO 865
      CC6B=0.0
      CM6B=0.0
      GOTO 870
  865 CONTINUE
      Q6B=0.6518*T6B*DA6
      V6B=0.02715*S6B*DA6
      CALL CCL(ILEV6B,Q6B,CCT6B)
      CALL CML(ILEV6B,Q6B,OMT6B)
      C1=CCDIS(Q6B)
      CM1=CMDIS(Q6B)
      CCT6B=CCT6B+C1
      CMT6B=CMT6B+OM1
      CCS6B=CCSWR(V6B)
      CMS6B=CMS(V6B)
      CC6B=(CCT6B+CCS6B)*NTP6
      CM6B=(OMT6B+CMS6B)*NTP6
C
C   C)   COMPUTE COSTS FOR SS REMOVAL FROM COMBINED WATERSHED
C
  870 CONTINUE
      IF(T5S.GT.0.0.AND.S5S.GT.0.0) GOTO 875
      CC5S=0.0
      CM5S=0.0
      GOTO 880
  875 CONTINUE
      Q5S=0.6518*T5S*DA5
      V5S=0.02715*S5S*DA5
      CALL CCL(ILEV5S,Q5S,CCT5S)
      CALL CML(ILEV5S,Q5S,OMT5S)
      C1=CCDIS(Q5S)
      CM1=CMDIS(Q5S)
      CCT5S=CCT5S+C1
      CMT5S=CMT5S+OM1
      CCS5S=CCCS(V5S)
      OMS5S=OMS(V5S)
      CC5S=(CCT5S+CCS5S)*NTP5
      CM5S=(CMT5S+OMS5S)*NTP5
C
C   D)   COMPUTE COSTS FOR SS REMOVAL FROM STORMWATER WATERSHED
C
  880 CONTINUE
      IF(T6S.GT.0.0.AND.S6S.GT.0.0) GOTO 885
      CC6S=0.0
      CM6S=0.0
      GOTO 890
  885 CONTINUE
      Q6S=0.6518*T6S*DA6
      V6S=0.02715*S6S*DA6
      CALL CCL(ILEV6S,Q6S,CCT6S)
      CALL CML(ILEV6S,Q6S,OMT6S)
      C1=CCDIS(Q6S)
      CM1=CMDIS(Q6S)
      CCT6S=CCT6S+C1
      CMT6S=CMT6S+OM1
      CCS6S=CCSWR(V6S)
      CMS6S=OMS(V6S)
      CC6S=(CCT6S+CCS6S)*NTP6
      CM6S=(CMT6S+OMS6S)*NTP6
890   CONTINUE
C
C   *  DETERMINE WHICH POLLUTANT CONTROLS NEEDS AND
C   *  ESTABLISH NEEDS
C
C
C   A)    COMBINED SEWER
C
      CCBOD5=CC5B+CMPB5
      CCSS5=CC5S+CMPS5
      IF(CCBOD5.GE.CCSS5) I5=1
      IF(CCBOD5.LT.CCSS5) I5=2
C  FOR I5=1
      IF(I5.NE.1) GOTO 900
      FWLC5=CCBOD5
      FWLCM5=CM5B+OMMRB5
      XSW5=XSWB5
      XSF5=XSFB5
      TLFW5=ILEV5B
      QFW5=T5B
      SFW5=S5B
      GOTO 950
900   CONTINUE
C FOR I5=2
      FWLC5=CCSS5
      FWLCM5=CM5S+OMMRS5
      XSW5=XSWS5
      XSF5=XSFS5
      TLFW5=ILEV5S
      QFW5=T5S
      SFW5=S5S
950   CONTINUE
C
C   B)    STORMWATER RUNOFF
C
      CCBOD6=CC6B+CMPB6
      CCSS6=CC6S+CMPS6
C SET SWR INDICATOR
      IF(CCBOD6.GE.CCSS6) I6=1
      IF(CCBOD6.LT.CCSS6) I6=2
C  FOR I6=1
      IF(I6.NE.1) GOTO 1050
      FWLC6=CCBOD6
      FWLCM6=CM6B+OMMRB6
      XSW6=XSWB6
      TLFW6=ILEV6B
      QFW6=T6B
      SFW6=S6B
      GOTO 1100
1050  CONTINUE
C  FOR I6 = 2
      FWLC6=CCSS6
      FWLCM6=CM6S+OMMRS6
      XSW6=XSWS6
      ILFW6=ILEV6S
      QFW6=T6S
      SFW6=S6S
 1100 CONTINUE
C
C   SAVE CONTROLLING STORAGE AND TREATMENT VALUES FOR RECREATION
C   CRITERIA LEVELS
      IF(I5.NE.1)GOTO 1150
      SSAV5=S5B
      TSAV5=T5B
      ILEV5=ILEV5B
 1150 CONTINUE
      IF(I5.NE.2)GOTO 1200
      SSAV5=S5S
      TSAV5=T5S
      ILEV5=ILEV5S
 1200 CONTINUE
      IF(I6.NE.1)GOTO 1250
      SSAV6=S6B
      TSAV6=T6B
      ILEV6=ILEV6B
 1250 CONTINUE
      IF(I6.NE.2)GOTO 1300
      SSAV6=S6S
      TSAV6=T6S
      ILEV6=ILEV6S
 1300 CONTINUE
C****************************************************
 1350 CONTINUE
C COMPUTE STORAGE VOLUME AND TREATMENT RATE
C REQUIRED FOR 2 OVERFLOW EVENTS PER YEAR
C
C
C  AR5  ANNUAL RUNOFF CSO (IN.)
C  D1      DURATION OF RUNOFF  FROM RRFW
C
C
C   IF S/T REQUIREMENTS FOR R&W ARE SMALL (I.E.
C   LEVEL 1 OR 2 ) SET ILEVEL =2 AND COMPUTE SSAV
C   AND TSAV BASED ON 95% CAPTURE BEFORE INCREASING
C   FACILITY SIZE TO MEET RECREATION CRITERIA
C
C   A)   COMBINED SEWER WATERSHED
C
      IF(CSAREA.LT.0.5)GOTO 1355
      IF(ILEV5.GE.3)GOTO 1355
      ILEV5=2
      DA5=CSAREA/NTP5
      IEPA=UANO/10000
      IT1=UANO-IEPA*10000
      IST=IT1/100
      CALL RAINRG(IST,IRG)
      CALL ISOPAR(IRG,B,H,D,F)
      T15=(AR5*95.0)/876000.0
      X56=B*EXP(H*95.0)
      Y56=D*EXP(-1.0*F*95.0)
      CALL STOPT(5,2,DA5,T15,X56,Y56,TSAV5,SSAV5)
C
C   B)   STORMWATER WATERSHED
C
 1355 CONTINUE
```

```
      IF(ILEV6.GE.3)GOTO 1360
      ILEV6=2
      DA6=SSAREA/NTP6
      IEPA=UANO/10000
      IT1=UANO-IEPA*10000
      IST=IT1/100
      CALL RAINRG(IST,IRG)
      CALL ISOPAR(IRG,B,H,D,F)
      T16=(AR6*95.0)/876000.0
      X56=B*EXP(H*95.0)
      Y56=D*EXP(-1.0*F*95.0)
      CALL STOPT(6,2,DA6,T16,X56,Y56,ISAV6,SSAV6)
 1360 CONTINUE
      S25=0.0653*AR5-0.0273*D1*100.0
C     S25=S25-0.27
      S26=0.0653*AR6-0.0273*D2*100.0
C     S26=S26-0.27
C
C   COMPUTE RATIO TO F & W STORAGE
C
      IF(SSAV5.EQ.0.0)R5=1.0
      IF(SSAV5.NE.0.0)R5=S25/SSAV5
      IF(R5.LT.1.0)R5=1.0
      IF(SSAV6.EQ.0.0)R6=1.0
      IF(SSAV6.NE.0.0)
     1 R6=S26/SSAV6
      IF(R6.LT.1.0)R6=1.0
C
C   SCALE UP FACILITIES TO MEET RECREATION OBJECTIVES
C
C   (IN.)
      S5=SSAV5*R5
      S6=SSAV6*R6
C   (IN/HR)
      T5=ISAV5*R5
      T6=ISAV6*R6
C   (MG)
      V5=0.02715*S5*DA5
      V6=0.02715*S6*DA6
C   (MGD)
      Q5=0.6518*T5*DA5
      Q6=0.6518*T6*DA6
C
C   *   COMPUTE COSTS OF SCALED UP FACILITIES
C
C   A)    COMBINED SEWER WATERSHED
C
      IF(CSAREA.GT.0.0)GOTO 1372
      RLC5=0.0
      RLOM5=0.0
      GOTO 1374
 1372 CONTINUE
      CALL CCL(ILEV5,Q5,CCT5)
      CCD5=CCDIS(Q5)
      CCS5=CCCS(V5)
      RLC5=(CCD5+CCT5+CCS5)*NTP5
      CALL CML(ILEV5,Q5,OMT5)
       OMD5=CMDIS(Q5)
      OMS5=OMS(V5)
      RLOM5=(OMT5+OMD5+OMS5)*NTP5
C
```

```
C   B)   STORMWATER WATERSHED
C
1374   CONTINUE
       CALL CCL(ILEV6,Q6,CCT6)
       CCD6=CCDIS(Q6)
       CCS6=CCSWR(V6)
       RLC6=(CCT6+CCD6+CCS6)*NTP6
       CALL CML(ILEV6,Q6,OMT6)
       CMD6=CMDIS(Q6)
       CMS6=OMS(V6)
       RLOM6=(CMT6+OMD6+OMS6)*NTP6
C*****************************************************
C COMPUTE CAPITAL COST OF SEWER SEPARATION -CCSS
C
       CCSS=0.0
       IF(CSAREA.GT.0.0)CCSS=1779.0*CSPOP*1.25*CF
C*****************************************************
C   ADJUST ALL COSTS BY CITY COST  FACTOR AND INCREASE ALL
C   CAPITAL COSTS BY 25 % FOR PLANNING, DESIGN, ETC.
C
       ALC5=ALC5*1.25*CF
       ALC6=ALC6*1.25*CF
       FWLC5=FWLC5*1.25*CF
       FWLC6=FWLC6*1.25*CF
       RLC5=RLC5*1.25*CF
       RLC6=RLC6*1.25*CF
C
       ALOM5=ALOM5*CF
       ALCM6=ALOM6*CF
       FWLCM5=FWLOM5*CF
       FWLCM6=FWLOM6*CF
       RLCM5=RLOM5*CF
       RLCM6=RLOM6*CF
C  IS THIS PRESENT CONDITIONS ?
C IS J=1
       IF(J.EQ.1)GOTO 1400
       GOTO 1550
C
C LOOK AT YEAR 2000 CONDITIONS
C YES
C
1400   CONTINUE
C*****************************************************
C   OUT PRESENT CONDITIONS
       PD=PD*100.0
       WRITE(8,1007)J,SEQ,UANO,UANM,CSAREA,CSPOP,UAPOP,UASZ,POP70,
     1 POP00,NCSC,NDR,RAIN,ICLASS,QUSF,PD,T,BOD,SS,PB,HARD,ALK,PH,
     1 CF,CNAT,I5,I6,ALC5,ALOM5,ALC6,ALOM6 ,FWLC5,FWLOM5,FWLC6,
     1 FWLOM6,RLC5,RLCM5,RLC6,RLOM6,CCSS,BODREM,SSREM,
     1 ILEV5,ILEV6,R5,R6,TLFW5,TLFW6,QFW5,QFW6,SFW5,SFW6,
     1 XSW5,XSW6,XSF5,T5,T6,S5,S6,NTP5,NTP6,
     1 VT,VT1,SSAREA,SSPOP
C
       J=2
C*****************************************************
C COMPUTE UA CHARACTERISTICS YR 2000 CONDITIONS
C UPDATE--
C   UAAREA,UAPOP,CSAREA,CSPOP,  CNAT ?
C *** KEEP TRACK OF PREVIOUS UA CHARACTERISTICS
C
       PSSP=SSPOP
```

```
      PSSA=SSAREA
      PCSA=CSAREA
      PCSP=CSPOP
C
C   *   OBPOP = 2000 STATE POP - OBERS
C   *   EPAPOP=                  - EPA
C
C   POP70 - 1970 UA POP - OBERS
C   POP00 - 2000
C
C   UAPOP - ACTUAL 1970 POP 1970
C   P2000 - UA POP 2000
      P2000=UAPOP*(POP00/POP70)*(EPA1(IST)/OBP(IST))
C
C   POPSS - 2000 UA POPULATION SERVED BY STORM SEWERS
C
C   WE ASSUME CSPOP DOESNT CHANGE I.E. ALL NEW UAPOP IS SSPOP.
C
      POPSS=P2000-CSPOP
      IF(POPSS.LT.1000.0) POPSS=1000.0
       SSAREA=POPSS/PDSS
      IF(SSAREA.LT.1000.0)SSAREA=1000.0
C  RESET FOR LATER USE
      UAPOP=P2000
      SSPOP=POPSS
      IF(SSPOP.LT.0.0)WRITE(6,1004)SEQ
      IF(SSPOP.LT.0.0)GO TO 50
C
C   RECOMPUTE TOTAL MILES FO STREET IN UA & IN STORMWATER AREA
C
C
C   *****************************************
C   *   MILES OF STREET IN URBANIZED AREA   *
C   *****************************************
C
      UAPOP=UAPOP/1000.0
      IF(UAPOP.GE.100.0) GOTO 1450
C FOR UAPOP LT 100,000
C
      TOTMIL=45.0+(UAPOP-10.0)*1.9444
      GOTO 1500
1450  CONTINUE
C  FOR UAPOP GT 100,000
C
      TOTMIL=220.0+(UAPOP-100.0)*1.9778
1500  CONTINUE
      UAPOP=UAPOP*1000.0
C
C   MILES - COMBINED SEWER AREA
C
      SMCS=TOTMIL*CSPOP/UAPOP
C
C   MILES - STORMWATER AREA
C
      SMSS=TOTMIL*SSPOP/UAPOP
      PD=PD/100.0
      GOTO 205
C*****************************************************
C THIS IS YEAR 2000 CONDITIONS
C
C NC
```

```
1550   CONTINUE
       PD=PD*100.0
       WRITE(8,1007)J,SEQ,UANO,UANM,CSAREA,CSPOP,UAPOP,UASZ,POP70,
     1 POP00,NCSC,NDB,RAIN,ICLASS,QUSF,PD,T,BCD,SS,PB,HARD,ALK,PH,
     1 CF,CNAT,I5,I6,ALC5,ALOM5,ALC6,ALOM6,FWLC5,FWLOM5,FWLC6,
     1 FWLOM6,RLC5,RLCM5,RLC6,RLOM6,CCSS,BCDREM,SSREM,
     1 ILEV5,ILEV6,R5,R6,TLFW5,TLFW6,QFW5,QFW6,SFW5,SFW6,
     1 XSW5,XSW6,XSF5,T5,T6,S5,S6,NTP5,NTP6,
     1 VT,VT1,SSAREA,SSPOP
       K=K+1
C****************************************************
C HAVE ALL UA'S BEEN EXAMINED ?
C IS K GT KMAX  (=320)
       IF(K.GT.KMAX)GOTO 1600
C NO THEN GO GET ANOTHER RECORD
       GOTO 50
C****************************************************
C
C
C YES ALL UA'S HAVE BEEN EXAMINED
C
1600   CONTINUE
99     CONTINUE
       STOP
       END
```

```
      REAL LCSO,LSWR,LWWTP,LUSF,NSPYR,LEN
C MEAN MONTHLY TEMP OF WATER FROM SURFACE SCURCES FOR JULY AND
C AUGUST,BY STATE CODE
      DIMENSION T(78)
      DATA T/80.0,55.0,0.0,80.0,82.0,78.0,0.0,65.0,70.0,75.0,
C23456
     1 75.0,85.0,80.0,0.0,90.0,68.0,75.0,75.0,75.0,77.0,
     1 77.0,83.0,65.0,75.0,70.0,70.0,70.0,81.0,77.0,65.0,
     1 75.0,70.0,68.0,75.0,75.0,70.0,77.0,67.0,75.0,80.0,
     1 68.0,73.0,0.0,70.0,80.0,72.0,78.0,83.0,73.0,68.0,
     1 75.0,0.0,65.0,75.0,70.0,65.0,0.0,0.0,0.0,90.0,
     1 0.0,0.0,0.0,0.0,0.0,90.0,0.0,0.0,0.0,0.0,
     1 0.0,90.0,0.0,0.0,90.0,0.0,0.0,90.0/
 1010 FORMAT(I4,F8.0,F8.0,I4,I4,I4,F8.0,F8.0,4F8.0)
 1011 FORMAT(3I4,2F8.0,3I4,4F8.0,2F8.4,7F14.0,2F6.2)
 1600 CONTINUE
C
C    ******************************************
C    *   PART II OF NEEDS ESTIMATION PROGRAM  *
C    *   THIS PART OF THE PROGRAM COMPUTES    *
C    *   CAT V NEEDS FOR COMBINED SEWER SYSTEMS*
C    *   LOCATED OUTSIDE OF URBANIZED AREAS   *
C    ******************************************
      K=1
      KMAX=56
 1610 CONTINUE
C
C   READ NON UA CAT V DATA
C
      READ(5,1010,END=99) ID,CSAREA,CSPOP,NCSS,NCSO,NDE,RAIN,QUSF,
C23456
     1 BOD,SS,CF,CNAT
      IEPA=ID/100
      IST=ID-IEPA*100
      IF(CSAREA.GT.0.5) GOTO 1700
      ALC=0.0
      ALOM=0.0
      FWC=0.0
      FWOM=0.0
      BLC=0.0
      BLOM=0.0
      CCSS=0.0
      GOTO 2500
 1700 CONTINUE
C
C    ****************************************************
C    *   COMPUTE COMBINED SEWER SYSTEM CHARACTERISTICS   *
C    ****************************************************
C
C
      PD=CSPOP/CSAREA
      X1=ALOG10(PD)
      X2=0.573-(0.0391*X1)
      CSIMP=9.6*(PD**X2)
      CSIMP=CSIMP/100.0
      BOCS=0.90*CSIMP+CNAT*(1.0-CSIMP)
      CSPOP=CSPOP/1000.0
      IF(CSPOP.GE.100.0) GOTO 1750
      TOTMIL=45.0+(CSPOP-10.0)*1.944
      GOTO 1800
 1750 CONTINUE
      TOTMIL=220.0+(CSPOP-100.0)*1.9778
```

```
1800   CONTINUE
       CSPOP=CSPOP*1000.0
C
C    COMPUTE ANNUAL POLLUTANT LOADS
C
       TE1=0.142+0.218*(PD**0.54)
       BODC=RAIN*(1.92*TE1+1.89)
       CSOBOD=BODC*CSAREA
C
       SSC=RAIN*(39.24*TE1+25.94)
       CSOSS=SSC*CSAREA
C
       WWBOD=9.12*CSPOP
       WWSS=9.12*CSPOP
C
       UFBOD=BOD*QUSF*1967.8
       UFSS=SS*QUSF*1967.8
C
C    ***********************************
CC    *   COMPUTE TOTAL WATER YIELD    *
C    ***********************************
C
       CSRUN=RUN(RAIN,ROCS,CSAREA)
       WWTP=1.547E-4*CSPOP
       QT=CSRUN+WWTP+QUSF
       AR5=RAIN*ROCS
C
CC    ******************************************
C    *   COMPUTE COSTS FOR AESTHETICS LEVEL   *
CC    ******************************************
C
       DA=CSAREA/NCSS
       NTP=(DA/1000.0)**0.435+0.5
       IF(NTP.LT.1) NTP=1
       DATP=DA/NTP
       NTP1=NCSS*NTP
       IF(NCSO.LT.NTP1)NCSO=NTP1
C
C    CAPITAL COST STREET SWEEPING
C
       CSW=TOTMIL*2.0*7.25*365*0.25
C
C    O&M COST STREET SWEEPING
C
       OMSW=TOTMIL*2.0*9.45*365*0.25
C
C    CAPITAL COST SEWER FLUSHING
C
       CSF=CSAREA*6105.0*0.13
C
C    O&M COST SEWER FLUSHING
C
       OMSF=CSAREA*724.0*0.13
C
C    SUM COSTS FOR AESTHETICS LEVEL
C
       ALC=CSW+CSF
       ALCM=OMSW+OMSF
C
C    ***********************************************
C    *   COMPUTE REMOVAL REQUIREMENTS FOR F & W    *
```

```
C   ***********************************************
C
C   A)   SUSPENDED SOLIDS
C
      QSS=62.4*24.0*3600.0*365*CSRUN
      CONSS=CSOSS*1.0E+6/QSS
      SSMAX=SS
      IF(SSMAX.LT.25.0) SSMAX=25.0
      IF(CONSS.LE.SSMAX) SSREM=0.0
      IF(CONSS.LE.SSMAX) GOTO 1850
      SSREM=(CONSS-SSMAX)/CONSS
      SSREM=100.0*SSREM
      IF(SSREM.LT.40.0) SSREM=40.0
1850  CONTINUE
C
C   B)   BOD (FROM SITE STUDIES ASSUME SWRBOD=CSOBOD )
C
      LCSO=CSOBOD
      ISWR=CSOBOD
      LWWTP=WWBOD
      LUSF=UFBOD
      IF(QUSF.LE.0.5) BODREM=80.0
      IF(QUSF.LE.0.5) GOTO 1900
      RWK=153.6*QUSF**(-0.5882)
      IF(RWK.GT.10.2) RWK=10.2
      IF(RWK.LT.0.176) RWK=0.176
      NSPYR=1.0022*NDF-2.58
      D1=0.6*9.94*NSPYR
      D1=D1/8760.0
      D2=0.5*9.94*NSPYR
      D2=D2/8760.0
      SSRUN=4.31*CSRUN
      QWW=QUSF+WWTP+CSRUN/D1+SSRUN/D2
      QDW=QUSF+WWTP
      CSOQP=(LCSO*0.40)/(D1*8760.0)
      SWRQP=(ISWR*0.16)/(D2*8760.0)
       USFQP=(LUSF*0.16)/8760.0
      WWTPQP=(LWWTP*0.23)/8760.0
      WWQP=(CSOQP+SWRQP+USFQP+WWTPQP)/(QWW*RWK)
      DWQP=(USFQP+WWTPQP)/(QDW*RWK)
      VT=0.0
      VT1=0.0
      T1=T(IST)
      DOSAT=14.652-0.410222*T1+0.00799*(T1**2)-0.00007777*(T1**3)
      DWDO=DOSAT-1.66
      VT=1013.0+864.0*DWQP+256.0*WWQP-204.0*DWDO
C     VT=VT+353.0
      IF(VT.LE.4.0) BODREM=0.0
      IF(VT.LE.4.0) GOTO 1900
C
C   W/C CSO
C
      WWQP1=(USFQP+WWTPQP+SWRQP)/(QWW*RWK)
      VT1=1013.0+864.0*DWQP+256.0*WWQP1-204.0*DWDO
C     VT1=VT1+353.0
C
C   CAN DO CRITERIA BE MET ?
C
      IF(VT1.GT.4.0)BODREM=90.0
      IF(VT1.GT.4.0)GOTO 1900
C
```

```
C   REMOVAL REQ. IF CRITERIA CAN BE MET
C
      WWQP2=(204.0*DWDO-864.0*DWQP-1009.0)/256.0
      X=(WWQP-WWQP2)/(WWQP-WWQP1)
      BODREM=100.0*X
1900  CONTINUE
      IF(BODREM.LT.40.0)BODREM=40.0
C
C   ***************************************************
C   *   DETERMINE MP'S - LEVEL OF EFFORT AND COSTS   *
C   ***************************************************
C
      RRB5=BODREM
      RRS5=SSREM
      CALL SSCW(RRB5,XSWB5)
      CALL SSCW(RRS5,XSWS5)
      CALL SFCS(RRB5,XSFB5)
      CALL SFCS(RRS5,XSFS5)
C
C   CAPITAL COST STREET SWEEPING
C
      CCSWB5=TOTMIL*2.0*7.25*365*XSWB5
      CCSWS5=TOTMIL*2.0*7.25*365*XSWS5
C
C   O&M COST STREET SWEEPING
C
      CMSWB5=TOTMIL*2.0*9.45*365*XSWB5
      CMSWS5=TOTMIL*2.0*9.45*365*XSWS5
C
C   CAPITAL COST SEWER FLUSHING
C
      CSFB5=CSAREA*6105.0*XSFB5
      CSFS5=CSAREA*6105.0*XSFS5
C
C    O&M COST SEWER FLUSHING
C
      CMSFB5=CSAREA*724.0*XSFB5
      CMSFS5=CSAREA*724.0*XSFS5
C
C   SUM COSTS
C
      CMPB5=CSWB5+CSFB5
      CMPS5=CSWS5+CSFS5
      CMMPB5=OMSWB5+OMSFB5
      OMMPS5=CMSWS5+OMSFS5
C
C   ************************************************
C   *   DETERMINE POLLUTANT REMOVAL FROM M P 'S   *
C   ************************************************
C
      YSWB5=TSW(XSWB5)
      YSWS5=TSW(XSWS5)
      YSFB5=TSW(XSFB5)
      YSFS5=TSW(XSFS5)
C
C
      FRSWB5=TFSW(0.24,PD,YSWB5)
      FRSWS5=TFSW(0.24,PD,YSWS5)
      FRSFB5=0.536*YSFB5
       FRSFS5=0.536*YSFS5
C
```

```
C   ********************************************
C   *   DETERMINE REMOVAL REQUIREMENTS FOR S/T   *
C   ********************************************
C
      TE1=RRB5-(FRSWB5+FRSFB5)*100.0
      TE2=100.0-100.0*(FRSWB5+FRSFB5)
      STB5X=TE1/TE2
      STB5X=STB5X*100.0
      IF(STB5X.LE.1.0)STB5X=0.0
C
      TE1=RRS5-(FRSWS5+FRSFS5)*100.0
      TE2=100.0-100.0*(FRSWS5+FRSFS5)
      STS5X=TE1/TE2
      STS5X=STS5X*100.0
      IF(STS5X.LE.1.0)STS5X=0.0
C
C   **************************************************
C   *   DETERMINE TREATMENT LEVEL REMOVAL EFFICIENCY   *
C   *   AND CAPTURE REQUIRED
C   **************************************************
C
      CALL LEVBO5(STB5X,ILEV5B)
      CALL LEVSS5(STS5X,ILEV5S)
      EB5=REB(ILEV5B)
      ES5=RES(ILEV5S)
C
C   COMPUTE CAPTURE REQUIRED
C
      C5B=STB5X/EB5
      C5S=STS5X/ES5
C
C   *******************************************************
C   *   COMPUTE ISOQUANT PARAMETERS & STORAGE & TREATMENT   *
C   *   VALUES                                              *[
C   *******************************************************
C
      T15B=(AR5*C5B)/876000.0
      T15S=(AR5*C5S)/876000.0
      CALL RAINRG(IST,IRG)
      CALL ISOPAR(IRG,B,H,D,F)
      X5B=B*EXP(H*C5B)
      X5S=B*EXP(H*C5S)
      Y5B=D*EXP(-1.0*F*C5B)
      Y5S=D*EXP(-1.0*F*C5S)
      IF(C5B.EQ.0.0)GOTO 1930
      CALL STOPT(5,ILEV5B,DATP,T15B,X5B,Y5B,T5B,S5B)
1930  IF(C5S.EQ.0.0)GOTO 1931
      CALL STOPT(5,ILEV5S,DATP,T15S,X5S,Y5S,T5S,S5S)
1931  CONTINUE
      IF(C5B.GT.0.0)GOTO 1935
      T5B=0.0
      S5B=0.0
1935  CONTINUE
      IF(C5S.GT.0.0)GOTO 1936
      T5S=0.0
      S5S=0.0
1936  CONTINUE
C
C   ****************************************
C   *   COMPUTE CAPITAL AND O&M COSTS FOR   *
C   *   STORAGE TREATMENT SYSTEMS           *
```

```
C     ****************************************
C
      IF(T5B.GT.0.0.AND.S5B.GT.0.0)GOTO 1940
      CC5B=0.0
      OM5B=0.0
      GOTO 1941
1940  CONTINUE
      Q5B=0.6518*T5B*DATP
      V5B=0.02715*S5B*DATP
      CALL CCI(ILEV5B,Q5B,CCT5B)
      CALL CMI(ILEV5B,Q5B,OMT5B)
      CCS5B=CCCS(V5B)
      CMS5B=CMS(V5B)
      C1=CCDIS(Q5B)
      CM1=CMDIS(Q5B)
      CCT5B=CCT5B+C1
      CMT5B=CMT5B+OM1
      CC5B=(CCT5B+CCS5B)*NTP1
      OM5B=(CMT5B+CMS5B)*NTP1
1941  CONTINUE
      IF(T5S.GT.0.0.AND.S5S.GT.0.0)GOTO 1942
      CC5S=0.0
      CM5S=0.0
      GOTO 1943
1942  CONTINUE
      Q5S=0.6518*T5S*DATP
      V5S=0.02715*S5S*DATP
      CALL CCI(ILEV5S,Q5S,CCT5S)
      CALL CMI(ILEV5S,Q5S,OMT5S)
      C1=CCDIS(Q5S)
      OM1=CMDIS(Q5S)
      CCT5S=CCT5S+C1
      CMT5S=CMT5S+OM1
      CCS5S=CCCS(V5S)
      CMS5S=CMS(V5S)
      CC5S=(CCT5S+CCS5S)*NTP1
      CM5S=(CMT5S+OMS5S)*NTP1
1943  CONTINUE
C
C     ****************************************************
CC    *   DETERMINE WHICH POLLUTANT CONTROLS NEEDS AND   *
C     *   ESTABLISH F & W NEEDS                          *
C     ****************************************************
C
      CCBOD5=CC5B+CMPB5
      CCSS5=CC5S+CMPS5
      IF(CCBOD5.GE.CCSS5) I5=1
      IF(CCBOD5.LT.CCSS5) I5=2
C
C     FOR I5=1 (BOD CONTROLS NEEDS)
C
      IF(I5.NE.1)GOTO 1950
      FWC=CCBOD5
      FWOM=CM5B+OMMPB5
      ILEV5=ILEV5B
      SSAV5=S5B
      TSAV5=T5B
      GOTO 2000
1950  CONTINUE
C
C     FOR I5=2 (SS CONTROLS NEEDS)
```

```
C
      FWC=CCSS5
      FWCM=CM5S+OMMPS5
      ILEV5=ILEV5S
      SSAV5=S5S
      TSAV5=T5S
 2000 CONTINUE
C
C   ***********************************************
C   *   RECREATION LEVEL --  COMPUTE STORAGE VOLUME   *
C   *   AND TREATMENT RATES FOR 2 OVERFLOW EVENTS PER *
C   *   YEAR                                          *
C   ***********************************************
C
C
C   IF S/T REQUIREMENTS FOR F&W ARE SMALL (I.E.
C   LEVEL 1 OR 2 ) SET ILEVEL =2 AND COMPUTE SSAV
C   AND TSAV BASED ON 95% CAPTURE BEFORE INCREASING
C   FACILITY SIZE TO MEET RECREATION CRITERIA
C
      IF(ILEV5.GE.3)GOTO 2100
      ILEV5=2
      DA5=CSAREA/NTP1
      IEPA=ID/100
      IST=ID-IEPA*100
      CALL RAINRG(IST,IRG)
      CALL ISOPAR(IRG,B,H,D,F)
      T15=(AR5*95.0)/876000.0
      X56=B*EXP(H*95.0)
      Y56=D*EXP(-1.0*F*95.0)
      CALL STOPT(5,2,DA5,T15,X56,Y56,TSAV5,SSAV5)
 2100 CONTINUE
C
      S25=0.0653*AR5-0.0273*D1*100.0
C     S25=S25+0.27
      IF(SSAV5.EQ.0.0)R5=1.0
      IF(SSAV5.NE.0.0)R5=S25/SSAV5
      IF(R5.LT.1.0)R5=1.0
      S5=SSAV5*R5
      T5=TSAV5*R5
      V5=S5*0.02715*DATP
      Q5=T5*0.6518*DATP
C
C   COMPUTE COST OF SCALED UP FACILITIES
C
      CALL CCL(ILEV5,Q5,CCT5)
      CCD5=CCDIS(Q5)
      CCS5=CCCS(V5)
      RLC=(CCT5+CCD5+CCS5)*NTP1
      CALL OMI(ILEV5,Q5,OMT5)
      OMD5=OMDIS(Q5)
      OMS5=OMS(V5)
      RLOM=(OMT5+OMD5+OMS5)*NTP1
C
C   ********************************************
C   *   COMPUTE CAPITAL COST OF SEWER SEPARATION  *
C   ********************************************
      CCSS=1779.0*CSPCP*1.25*CF
C
C   ********************************************
C   *   ADJUST ALL COSTS BY CITY COST FACTOR AND  *
```

```
C   *   INCREASE CAPITAL COSTS BY 25% FOR PLANNING *
C   *   DESIGN,ETC.                                *
C   ************************************************
C
      ALC=1.25*ALC*CF
      ALOM=CF*ALOM
      FWC=1.25*CF*FWC
      FWOM=FWCM*CF
      RLC=1.25*CF*RLC
      RLOM=CF*RLOM
2500  CONTINUE
      WRITE(8,1011)K,IEPA,IST,CSAREA,CSPOP,NCSS,NCSO,NDR,RAIN,
     1 QUSF,BOD,SS,CF,CNAT,ALC,ALOM,FWC,FWCM,RIC,RICM,CCSS,
     1 BODREM,SSREM
      K=K+1
      IF(K.GT.KMAX)GOTO 99
      GOTO 1610
3000  CONTINUE
99    CONTINUE
       STOP
C     DEBUG INIT
      END
C
C*********** ACS *************************
C
      SUBROUTINE ACS(V1,I,AC)
      IF(I.EQ.5)AC=61400.0*(V1**0.724)
      IF(I.EQ.6)AC=33500*(V1**0.621)
      RETURN
      END
C
C**************** ACT ***********************
C
      SUBROUTINE ACT (Q1,I,AC)
      GOTO (10,20,30,40,50),I
10    CONTINUE
      AC=35900.0*(Q1**0.609)
      GOTO 60
20    CONTINUE
      AC=78100.0*(Q1**0.700)
      GOTO 60
30    CONTINUE
      AC=122800.0*(Q1**0.727)
      GOTO 60
40    CONTINUE
      AC=157800.0*(Q1**0.688)
      GOTO 60
50    CONTINUE
      AC=213000.0*(Q1**0.711)
60    CONTINUE
      RETURN
      END
C
C*********** CCCS ********************
C
      FUNCTION CCCS (V)
C
C   *******************************************************
C   *   CAPITAL COST OF STORAGE FOR COMBINED SEWER AREA   *
C   *******************************************************
C
```

```
C V - TOTAL VOLUME IN MG
C
      V1=0.3 *V
      V2=0.7*V
      C1=465000.0*(V1**0.619)
      C2=528000.0*(V2**0.790)
      CCCS=C1+C2
      RETURN
      END
C
C************** CCDIS ***********************
C
      FUNCTION CCDIS (Q1)
C  ***********************************
C  *   CAPITAL COST- DISINFECTION    *
C  ***********************************
C
C Q1 - FLOW RATE IN MGD
C
      CCDIS=73100.0+6020.0*Q1
      RETURN
      END
C
C************** CCL **************************
C
      SUBROUTINE CCL (LEVEL,Q,CCT)
C
C    **************************************
C    *   COMPUTE CAPITAL COST BY LEVEL    *
C    **************************************
C
      CCT=0.0
C
C    **************
C    *  LEVEL 1   *
C    **************
C
C  ADMINISTRATION
C     -NONE---
C  LABORATORY
C   --NONE---
C
C  YARDWORK
C  --NONE---
C
C  WASTEWATER PUMPING
      CCWWP=113000.0*(Q**0.833)
      CCT=CCT+CCWWP
C  FLOWMEASUREMENT
      CCFM=3800.0*(Q**0.484)
      CCT=CCT+CCFM
      IF(LEVEL.LT.2)GOTO 99
C
C    ***************
C    *   LEVEL 2   *
C    ***************
C
C  COARSE SCREENING
      CS1=16700.0*(Q**0.972)
      CCT=CCT+CS1
C  MICROSCREENING
```

```
      XMS=35000.0*(Q**0.846)
      CCT=CCT+XMS
C  SLUDGE PUMPING (QS=0.10 Q)
      QS=Q*0.10
      SP2=288000.0*(QS**0.502)
      CCT=CCT+SP2
C  SLUDGE DISPOSAL
      SD2=58100.0*(Q**0.608)
      CCT=CCT+SD2
      IF(LEVEL.LT.3)GOTO 99
C   ***************
C   *   LEVEL 3   *
C   ***************
C
C  CHEMICAL MIXING
      CM3=55600.0*(Q**0.611)
      CCT=CCT+CM3
C  FLOCCULATION
      FL=30000.0*(Q**0.612)
      CCT=CCT+FL
C  SEDIMENTATION
      SED=52000.0*(Q**0.817)
      CCT=CCT+SED
C  SLUDGE PUMPING  (QS3=0.05 Q)

      QS3=Q*0.05
      SP3=288000.0*(QS3**0.502)
      CCT=CCT+SP3
C  SLUDGE DISPOSAL
      SD3=58100.0*(Q**0.608)
      CCT=CCT+SD3
      IF(LEVEL.LT.4)GOTO 99
C
C   ***************
C   *   LEVEL 4   *
C   ***************
C
C  HIGH RATE FILTRATION
      HRF=127000.0*(Q**0.735)
      CCT=CCT+HRF
      IF(LEVEL.LT.5)GOTO 99
C
C   ***************
C   *   LEVEL 5   *
C   ***************
C
C  CHEMICAL MIXING
      CM5=55600.0*(Q**0.611)
      CCT=CCT+CM5
C  DISSOLVED AIR FLOTATION
      DAF=163000.0*(Q**0.658)
      CCT=CCT+DAF
C  SLUDGE PUMPING (QS=0.05*Q)
      QS=0.05*Q
      SP5=288000*(QS**0.502)
      CCT=CCT+SP5
C  SLUDGE DISPOSAL
      SD5=58100.0*(Q**0.608)
      CCT=CCT+SD5
99    CONTINUE
```

```
      RETURN
      END
C
C*********** ISOPAR ****************************************
C
      SUBROUTINE ISOPAR (REG,B,H,D,F)
C
C    *   ENTER WITH REGION CODE
C    *   RETURN WITH B,H,D,F VALUES

      INTEGER REG
      GOTO (10,20,30,40,50),REG
10    CONTINUE
C  IN/HR
      B=0.0021654
C 1/(% R)
      H=0.0388910
C  1/IN
      D=211.2763
C  1/(%R)
      F=0.0320226
      GOTO 60
20    CONTINUE
      B=0.0013631
      H=0.0439822
      D=184.9639
      F=0.0279177
      GOTO 60
30    CONTINUE
      B=0.0013656
      H=0.0481981
      D=241.6141
      F=0.0301648
      GOTO 60
40    CONTINUE
      B=0.0025864
      H=0.0468175
      D=190.2240
      F=0.0312484
      GOTO 60
50    CONTINUE
      B=0.0018959
      H=0.0487876
      D=228.8434
      F=0.0339322
60    CONTINUE
      RETURN
      END
C
C*************** LEVBO5 *******************
C
      SUBROUTINE LEVBC5 (STB5,ILB5)
C
C    THIS SUBROUTINE PICKS THE TREATMENT LEVEL
C    FOR BOD REMOVAL FROM A COMBINED SEWER
C    WATERSHED
C
C STB5-BOD REMOVAL BY STORAGE/TREATMENT --%
C
      IF(STB5.LT.8.0)ILB5=1
      IF(STB5.GE.8.0.AND.STB5.LT.13.0)ILB5=2
      IF(STB5.GE.13.0.AND.STB5.LT.38.0)ILB5=3
      IF(STB5.GE.38.0.AND.STB5.LT.88.0)ILB5=4
      IF(STB5.GE.88.0)ILB5=5
      RETURN
      END
C
C*************** LEVSS5 ***********************
C
      SUBROUTINE LEVSS5 (STS5,ILS5)

C   THIS SUBROUTINE PICKS THE TREATMENT LEVEL FOR
C   SS REMOVAL FROM A COMBINED SEWER WATERSHED
C
      IF(STS5.LT.8.0)ILS5=1
      IF(STS5.GE.8.0.AND.STS5.LT.68.0)ILS5=2
      IF(STS5.GE.68.0.AND.STS5.LT.98.0)ILS5=3
      IF(STS5.GE.98.0)ILS5=4
      RETURN
      END
C
C************ CMDIS ********************
C
      FUNCTION CMDIS (Q1)
C
C   **********************************
C   *   O & M COST - DISINFECTION    *
C   **********************************
C
C Q1 - FLOW RATE IN MGD
C
C     LABOR
      ACLD=2060.0*(Q1**0.597)
C     SUPPLIES
      ACSD=1320.0*(Q1**0.690)
C TOTAL ***********
      CMDIS=ACLD+ACSD
      RETURN
      END
C
C**************** OML *********************
C
      SUBROUTINE OML (LEVEL,Q,OMT)
C
C   *****************************************************************
C   *   COMPUTE OPERATION & MAINTENANCE COST- BY LEVEL    *
C   *****************************************************************
C
      CMT=0.0
C
C   ***************
C   *   LEVEL 1   *
C   ***************
C
C  ADMINISTRATION
C **LABOR
      AL=232.0*(Q**0.463)
C **SUPPLIES
      AS=87.0*(Q**0.471)
      CMT=CMT+AS+AL
C  LABORATORY
C **LABOR
```

```
      OMT=OMT+9970.0                                                    00072600
C **SUPPLIES                                                            00072700
      OMT=OMT+2550.0                                                    00072800
C  YARDWORK                                                             00072900
C **LABOR                                                               00073000
      YL=1010.0*(Q**0.798)                                              00073100
C **SUPPLIES                                                            00073200
      YS=66.0*(Q**0.838)                                                00073300
      OMT=OMT+YL+YS                                                     00073400
C  WASTEWATER PUMPING                                                   00073500
C **LABOR                                                               00073600
      WWPL=4790.0*(Q**0.188)                                            00073700
C **SUPPLIES                                                            00073800
      WWPS=69.0*Q                                                       00073900
C **POWER                                                               00074000
      WWPP=140.0*Q                                                      00074100
      OMT=OMT+WWPL+WWPS+WWPP                                            00074200
C  FLOW MEASUREMENT                                                     00074300
C  --NONE---                                                            00074400
      IF(LEVEL.LT.2)GOTO 99                                             00074500
C                                                                       00074600
C   ****************                                                    00074700
C   *   LEVEL 2    *                                                    00074800
C   ****************                                                    00074900
C                                                                       00075000
C  COARSE SCREENING                                                     00075100
C **LABOR                                                               00075200
      CSL=3880.0*(Q**0.287)                                             00075300
C **SUPPLIES                                                            00075400
      CSS=848.0*(Q**0.273)                                              00075500
      OMT=OMT+CSL+CSS                                                   00075600
C  MICROSCREENING                                                       00075700
C **LABOR                                                               00075800
      XMSL=CSL                                                          00075900
C **SUPPLIES                                                            00076000
      XMSS=CSS                                                          00076100
      OMT=OMT+XMSL+XMSS                                                 00076200
C  SLUDGE PUMPING (QS = 0.10 Q)                                         00076300
      QS=0.10*Q                                                         00076400
C **LABOR                                                               00076500
      SPL2=9600.0*(QS**0.413)                                           00076600
C **SUPPLIES                                                            00076700
      SPS2=1100.0*(QS**0.643)                                           00076800
C **POWER                                                               00076900
      SPP2=145.0*QS                                                     00077000
      OMT=OMT+SPL2+SPS2+SPL2                                            00077100
C  SLUDGE DISPOSAL                                                      00077200
      SDL2=9950.0*Q                                                     00077300
      OMT=OMT+SDL2                                                      00077400
      IF(LEVEL.LT.3)GOTO 99                                             00077500
C                                                                       00077600
C   ***************                                                     00077700
C   *   LEVEL 3   *                                                     00077800
C   ***************                                                     00077900
C                                                                       00078000
C  CHEMICAL MIXING                                                      00078100
C **LABOR                                                               00078200
      CML3=4020.0*(Q**0.332)                                            00078300
C **SUPPLIES                                                            00078400
      CMS3=41.7*(Q**0.662)                                              00078500
C **POWER                                                               00078600
```

```
      CMP3=23.0*(Q**0.86)
      CMT=CMT+CML3+CMS3+CMP3
C  FLOCCULATION
C **LABOR
      FLL=392.0*Q
C **SUPPLIES
      FLS=206.0*(Q**0.641)
C **POWER
      FLP=63.0*Q
      CMT=CMT+FLL+FLS+FLP
C  SEDIMENTATION
C **LABOR
      SEDL=3870.0*(Q**0.702)
C **SUPPLIES
      SEDS=1520.0*(Q**0.212)
C **POWER
      SEDP=4.15*(Q**0.779)
      CMT=CMT+SEDL+SEDS+SEDP
C  SLUDGE PUMPING (QS3=0.05 Q)
      QS3=0.05*Q
C **LABOR
      SPL3=9600.0*(QS3**0.413)
C **SUPPLIES
      SPS3=1100.0*(QS3**0.643)
C **POWER
      SPP3=145.0*QS3
      CMT=CMT+SPL3+SPS3+SPP3
C  SLUDGE DISPOSAL
C
      SD3=9950.0*Q
      CMT=CMT+SD3
      IF(LEVEL.LT.4)GOTO 99
C
C   ***************
C   *   LEVEL 4   *
C   ***************
C
C  HIGH RATE FILTRATION
C **LABOR
      HRFL=27600.0+29.0*Q
C **SUPPLIES
      HRFS=1020.0*(Q**0.237)
C **POWER
      HRFP=16.7*Q
      CMT=CMT+HRFL+HRFS+HRFP
      IF(LEVEL.LT.5)GOTO 99
C
C   ***************
C   *   LEVEL 5   *
C   ***************
C
C  CHEMICAL MIXING
C **LABOR
      CML5=4020.0*(Q**0.332)
C **SUPPLIES
      CMS5=41.7*(Q**0.662)
C **POWER
      CMP5=23.0*(Q**0.86)
      CMT=CMT+CML5+CMS5+CMP5
C  DISSOLVED AIR FLOTATION
C **LABOR
```

```
      DAFL=3260.0*(Q**0.618)
C **SUPPLIES
      DAFS=4770.0*(Q**0.870)
C **POWER
      DAFP=1180.0*Q
      CMT=CMT+DAFL+DAFS+DAFP
C  SLUDGE PUMPING (QS5=0.05 Q)
C **LABOR
      SPL5=SPL3
C **SUPPLIES
      SPS5=SPS3
C **POWER
      SPP5=SPP3
      CMT=CMT+SPL5+SPS5+SPP5
C  SLUDGE DISPOSAL
      SD5=SD3
      CMT=CMT+SD5
99    CONTINUE
      RETURN
      END
C
C******************** OMS **************************
C
      FUNCTION CMS (V)
C
C   ********************************************
C   *   OPERATION AND MAINTENACE COST-STORAGE   *
C   ********************************************
C
C  LABOR
      ACLS=2670*(V**0.509)
C  SUPPLIES
      ACSS=618*(V**0.405)
C  POWER
      ACPS=15.8*(V**0.493)
      CMS=ACLS+ACSS+ACPS
      RETURN
      END
C
C************ RAINRG ***************************************
C
      SUBROUTINE RAINRG (ST,REG)
      INTEGER ST,REG
C   *   ENTER WITH STATE CODE
C   *   RETURN WITH REGION CODE
C
      IF(ST.EQ.6.OR.ST.EQ.15.OR.ST.EQ.60) GOTO 10
      IF(ST.EQ.66.OR.ST.EQ.75.OR.ST.EQ.2) GOTO 10
      IF(ST.EQ.41.OR.ST.EQ.53) GOTO 10
C
      IF(ST.EQ.4.OR.ST.EQ.32.OR.ST.EQ.35) GOTO 20
      IF(ST.EQ.8.OR.ST.EQ.30.OR.ST.EQ.49) GOTO 20
      IF(ST.EQ.56.OR.ST.EQ.16) GOTO 20
C
      IF(ST.EQ.17.OR.ST.EQ.18.OR.ST.EQ.26) GOTO 30
      IF(ST.EQ.27.OR.ST.EQ.39.OR.ST.EQ.55) GOTO 30
      IF(ST.EQ.19.OR.ST.EQ.20.OR.ST.EQ.29) GOTO 30
      IF(ST.EQ.31.OR.ST.EQ.40.OR.ST.EQ.48) GOTO 30
      IF(ST.EQ.38.OR.ST.EQ.46) GOTO 30
C
      IF(ST.EQ.72.OR.ST.EQ.78.OR.ST.EQ.1) GOTO 40
      IF(ST.EQ.12.OR.ST.EQ.28.OR.ST.EQ.37) GOTO 40
      IF(ST.EQ.45.OR.ST.EQ.47.OR.ST.EQ.5) GOTO 40
      IF(ST.EQ.22.OR.ST.EQ.13) GOTO 40
C
      IF(ST.EQ.9.OR.ST.EQ.23.OR.ST.EQ.25) GOTO 50
      IF(ST.EQ.33.OR.ST.EQ.44.OR.ST.EQ.50) GOTO 50
      IF(ST.EQ.10.OR.ST.EQ.11.OR.ST.EQ.24) GOTO 50
      IF(ST.EQ.42.OR.ST.EQ.51.OR.ST.EQ.54) GOTO 50
      IF(ST.EQ.34.OR.ST.EQ.36.OR.ST.EQ.21) GOTO 50
      GOTO 60
10    CONTINUE
      REG=1
      GOTO 60
20    CONTINUE
      REG=2
      GOTO 60
30    CONTINUE
      REG=3
      GOTO 60
40    REG=4
      GOTO 60
50    CONTINUE
      REG=5
60    CONTINUE
      RETURN
      END
C
C***************** REB *********************
C
      FUNCTION REB (IL)
      GOTO (10,20,30,40,50),IL
C   THIS FUNCTION ASSIGNS REMOVAL EFFECIENCIES
C   TO TREATMENT LEVELS
C
10    CONTINUE
      REB=0.25
      GOTO 60
20    CONTINUE
      REB=0.51
      GOTO 60
30    CONTINUE
      REB=0.81
      GOTO 60
40    CONTINUE
      REB=0.91
      GOTO 60
50    CONTINUE
      REB=0.96
60    CONTINUE
      RETURN
      END
C
C***************** RES ********************
C
      FUNCTION RES (IL)
      GOTO (10,20,30,40,50),IL
C   THIS FUNCTION ASSIGNS REMOVAL EFFECIENCIES TO
C TREATMENT LEVELS FOR SS
C
10    CONTINUE
      RES=0.30
      GOTO 60
20    CONTINUE
      RES=0.86
      GOTO 60
30    CONTINUE
      RES=0.97
      GOTO 60
40    CONTINUE
      RES=0.99
      GOTO 60
50    CONTINUE
      RES= 1.00
60    CONTINUE
      RETURN
      END
C
C*************** RUN ********************************
C
      FUNCTION RUN (RAYN,XIMP,AREA)
C
C   COMPUTE RUNOFF IN CFS
C
C  -INCHES
      RN=RAYN*XIMP
C  -AC-FT
      RN=RN*AREA/12.0
C FT**3
      RN=RN*43560.0
C FT**3/SEC
      RUN=RN/31536000.0
      RETURN
      END
C
C****************** SFCS ***********************

      SUBROUTINE SFCS (RR,XSF)
C
C   ******************************************
C   *   SEWER FLUSHING--COMBINED WATERSHED   *
C   ******************************************
C
C   * ENTER WITH REMOVAL REQUIREMENTS
C   *   RETURN WITH LEVEL OF EFFORT REQUIRED
C
      IF(RR.LT.8.0)GOTO 10
      IF(RR.LE.25.0)GOTO 20
      IF(RR.LT.42.0)GOTO 30
      IF(RR.LE.75.0)GOTO 40
      IF(RR.LE.94.0)GOTO 50
      GOTO 60
10    CONTINUE
C  RR ON THE INTERVAL 0 TO 8
      XSF=0.0
      GOTO 70
20    CONTINUE
C RR ON THE INTERVAL 8 TO 25
      RR1=RR-8.0
      XSF=(RR1/17.0)*0.033
      GOTO 70
30    CONTINUE
C RR ON THE INTERVAL 25 TO 42
```

```
      RR1=RR-25.0
      XSF=0.033+(RR1/17.0)*0.067
      GOTO 70
40    CONTINUE
C RR ON THE INTERVAL 42 TO 75
      XSF=0.033
      GOTO 70
50    CONTINUE
C RR ON THE INTERVAL 75 TO 94
      RR1=RR-75.0
      XSF=(19.0-RR1)/19.0*0.033
      GOTO 70
60    CONTINUE
C RR ON THE INTERVAL 94 TO 100
      XSF=0.0
70    CONTINUE
      RETURN
      END
C
C********************* SSCW ***********************:
C
      SUBROUTINE SSCW (RR,XSW)
C
C    ******************************************
C    *   STREETSWEEPING COMBINED WATERSHEDS   *
C    ******************************************
C
C    *   ENTER WITH REMOVAL REQUIREMENTS
CC   *    RETURN WITH LEVEL OF EFFORT REQUIRED
C
      IF(RR.LT.39.0)GOTO 10
      IF(RR.LT.73.0)GOTO 20
      GOTO 30
10    CONTINUE
C  RR ON THE INTERVAL 0 TO 39
      XSW=(RR/39.0)*0.235
      GOTO 40
20    CONTINUE
C   RR ON THE INTERVAL 39 TO 73
      RR1=RR-39.0
      XSW=0.14
      GOTO 40
30    CONTINUE
C   RR ON THE INTERVAL 73 TO 100
      RR1=RR-73.0
      XSW=0.14-(RR1/27.0)*0.137
40    CONTINUE
      RETURN
      END
C
CC************** STOPT ********************
C
      SUBROUTINE STOPT (IT1,IL1,D,T1,X,Y,T,S)
C
C    ***************************************
C    *   STORAGE-TREATMENT OPTIMIZATION   *
C    ***************************************
      N=1
      DELTAT=X/100.0
      IF(DELTAT.GT..001)DELTAT=0.001
      TC=T1+DELTAT
```

```
 10     CONTINUE                                                        00109200
        SC=ALOG(X/(TC-T1))/Y                                            00109300
        IF(SC.LE.0.0) GOTO 50                                           00109400
        Q=TC*0.6518*D                                                   00109500
        V=SC*0.02715*D                                                  00109600
        CALL ACS (V,IT1,ACSTOR)                                         00109700
        CALL ACT (Q,IT1,ACTR)                                           00109800
        ACC=ACSTOR+ACTR                                                 00109900
        IF(N.EQ.1)GOTO 100                                              00110000
        DAC=ACC-ACP                                                     00110100
        IF(DAC.LT.0.0)GOTO 100                                          00110200
 50     CONTINUE                                                        00110300
        T=TP                                                            00110400
        S=SP                                                            00110500
        GOTO 200                                                        00110600
C LOOK AT NEXT STEP                                                      00110700
 100    N=N+1                                                           00110800
        ACP=ACC                                                         00110900
        TP=TC                                                           00111000
        SP=SC                                                           00111100
        TC=TP+DELTAT                                                    00111200
        GOTO 10                                                         00111300
 200    CONTINUE                                                        00111400
        RETURN                                                          00111500
        END                                                             00111600
C                                                                       00111700
C************** TFSW *******************                                 00111800
C                                                                       00111900
        FUNCTION TFSW (C,PD,YSW)                                        00112000
C **  TRANSFORM YSW TO FRSW                                             00112100
        TFSW=C*(0.67-0.00762*PD)*YSW                                    00112200
        RETURN                                                          00112300
        END                                                             00112400
C                                                                       00112500
C*************** TSW *******************                                 00112600
C                                                                       00112700
        FUNCTION TSW (XSW)                                              00112800
C **  TRANSFORM XSW TO  YSW                                             00112900
        X1=0.08909*XSW                                                  00113000
        X2=0.10547*XSW                                                  00113100
        TSW=X1/(0.00589+X2)                                             00113200
        RETURN                                                          00113300
        END                                                             00113400
```

APPENDIX E

CORRESPONDENCE

Copies of the November 1978 draft report were sent to each State Water Pollution Control Director, State Needs Survey Director, Interstate Water Pollution Control Commission, and EPA regional office as well as to numerous other individuals during November 1978. It was requested that written comments on the draft report be submitted by 30 December 1979.

Meetings were held on 6 and 7 December in Chicago and Washington, D.C., to present the report and receive verbal comments from the various reviewers.

This appendix presents written comments received on the draft report and EPA response to these comments. Lengthy attachments and additional data received from the reviewers are not reproduced here.

STATE OF CALIFORNIA—THE RESOURCES AGENCY
EDMUND G. BROWN JR., Governor

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER QUALITY
P. O. BOX 100 • SACRAMENTO 95801
(916) 445-7971

In Reply Refer
to: RM

DEC 29 1978

Mr. Philip Graham
U. S. Environmental Protection Agency
(WH-595)
401 "M" Street
Washington, DC 20460

"1978 NEEDS SURVEY, COST METHODOLOGY FOR CONTROL OF COMBINED SEWER OVERFLOW AND STORMWATER DISCHARGE" AND "1978 NEEDS SURVEY, CONTINUOUS STORMWATER POLLUTION SIMULATION SYSTEM USERS MANUAL"

We have received the above documents and appreciate the opportunity to provide comment.

Our comments center around our conviction that the 1978 EPA estimate for Category V needs in California is extremely low, as was the case with the 1976 estimate. Our preliminary estimate of Category V needs, submitted on the Category V worksheets, of $1,186,676,000 is 444 percent higher than the EPA estimate of $266,981,000 (Recreation Water Quality Goal). We request that the EPA estimate be raised to the higher figure. It is a good approximation of the grant-eligible dollars that are planned to be spent on combined sewers in California over the next few years.

Our contention is based on the status of San Francisco's combined sewer project. Of our submitted estimate, $1,136,000,000 (95.7 percent) was for San Francisco. This figure represents that portion of the San Francisco project allocable to wet weather (combined sewer) flows and was broken out by the City of San Francisco's consulting engineers, Metcalf and Eddy. This project is nearing completion of planning, within the framework of the 201 Grant Program, with concept approval already given to many project elements.

The enclosed letter from the City of San Francisco includes updated cost estimates for the facilities needed to solve their water quality problems due to wet weather flow. This information must be considered carefully. The cost estimates originally supplied on the worksheets were for a City system designed to accommodate a one overflow per year requirement. The attached, updated cost estimates are for a City system allowing four overflows per year. The City is currently applying for overflow relaxations, however, it is uncertain at this time what they might obtain from our Regional Board and EPA Region IX.

The City's updated cost estimates must also be recognized as presenting the costs as of the estimated construction bid advertising date. With the assistance of the City staff, we have refined these costs to a December, 1977 (ENR 3200) basis including a developed proration of 75 percent of sludge processing and handling costs devoted to wet weather flows. The backup to this refinement is the Metcalf and Eddy raw data summary sheet included with San Francisco's letter. This effort resulted in an estimated cost of $869.9 million as of January 1, 1978, for the Category V needs in San Francisco assuming a four overflow per year requirement.

The Needs Survey reporting criteria required that reporting be on the basis of actual circumstances as of January 1, 1978. In this context, the requirements applicable to San Francisco were one overflow per year and the originally submitted need of $1.136 billion (which was ENR 3200) remains accurate. However, should San Francisco succeed in obtaining a relaxation of requirements to four overflows per year, their Category V need would be $869.9 million.

Therefore, we estimate that total State needs will range from $920,576,000 to $1,186,676,000 depending on whether the overflow relaxation is granted San Francisco.

We call your attention to the "Needs Met Before 1978" estimate included in your report. We estimate $125 million in needs have been satisfied through Step 3 grant offers prior to January 1, 1978, rather than your reported figure of $48.765 million.

The modeling technique used by the EPA to estimate Category V needs, while sophisticated and well thought out, is still only a model and has less validity than actual cost estimates. This model should not be applied to California because of the fact that essentially all of our combined sewer needs are localized in a single area, San Francisco, for which combined sewer needs are known. To use the modeling technique instead of the actual cost estimates in determining Category V needs contradicts the basic philosophy of the Needs Survey to always use available and actual engineering cost estimates over any type of artificial needs estimation technique.

Finally, the recently published EPA regulations implementing the Clean Water Act Amendments of 1977 state that, "The State project priority list shall be consistent with the needs inventory" (40 CFR 35.915(b)). If the low EPA Category V estimate for California is not raised significantly, California's priority list estimated cost for San Francisco's combined sewer project will be inconsistent with the Needs Survey. If this is the case, we would like written assurance that this inconsistency will not in any way inhibit the progress or alternative selection process of the San Francisco project.

Our case for an increase in Category V needs for California is a strong and defensible one and we hope you will seriously consider raising the Category V needs estimate for California to a more realistic figure. If no raise in the estimate is made by EPA, we request that a separate Category V State estimate of $1,186,676,000 be made for California in the Report to Congress. Randy Marx of our staff will be available to discuss this issue with you.

Raymond J Walsh
for Neil Dunham
Division Chief
Manager - Clean Water Grant Program

Enclosures

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER AND
HAZARDOUS MATERIALS

FEB 2 1979

Mr. Neil Dunham
Division Chief
Manager, Clean Water Grant Program
State Water Resources Control Board
Division of Water Quality
P. O. Box 100
Sacramento, California 95801

Dear Mr. Dunham:

Thank you for your review dated December 29, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff.

Based on our experience with the Category V and VI portions of the Needs Survey, your estimate of Category V needs for the city of San Francisco of $1,136,000,000 appears high. There is, of course, uncertainty in the needs estimate, and this uncertainty is discussed in Chapter 15 of the final report (FRD-3). The Environmental Protection Agency (EPA) estimate, before adjustment for $125,000,000 of met needs, is $272,621,000. On a per acre of combined sewer area basis the State and EPA estimates respectively are 31,146 $/acre and 7,155 $/acre. For comparison purposes, the national average cost estimated by EPA to control pollution from combined sewer overflows is $10,752 per acre. The estimate presented by the State of California is approximately three times this national average cost. Most of this difference is due to the cost estimates for the city of San Francisco.

The differences between the EPA and State estimate for San Francisco result largely from different assumptions on appropriate control technology, in particular the optimal mix of storage and treatment capacity. EPA's estimate is derived from the model which is based on an intensive analysis of available research and other information on control technologies and the 15 site studies.

The model provides the advantage of producing needs estimates which are comparable among the States and based on reasonable and common assumptions. It is unlikely to provide the same answer in every city as would detailed facility planning. We understand, however, that San Francisco and the State of California have been considering revisions which would bring their current estimate needs for San Francisco closer to the EPA estimate.

Needs met before 1978 will be changed from $48,765,000 to $125,000,000 in the final report.

The final report, including all comments and corrections received from the States, will be forwarded to you in March 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF ENVIRONMENTAL SERVICES
BUREAU OF DESIGN AND ENGINEERING

ADDRESS REPLY TO:
5000 OVERLOOK AVENUE, S.W.
WASHINGTON, D.C. 20032

E&C-4.25

DEC 11 1978

Mr. Philip Graham
Environmental Protection Agency (WH-595)
401 M Street, S.W.
Washington, D.C. 20460

SUBJECT: 1978 Needs Survey, Categories V and VI

Dear Mr. Graham:

Enclosed are the combined sewer system worksheets (1978 Needs Survey) and copy of the pages of the CSO reconnaissance study with the information requested by EPA in transmittal letter of Novmeber 20, 1978.

If you desire further information or assistance in this matter, please contact Mr. Rodolfo Gutierrez of our staff at 767-7614.

Sincerely yours,

KENNETH L. DONNELLY, P.E.
Chief, Engineering Division

Enclosures

RG:ec

cc: Mr. Slocum
Mr. Bass (w/encl.)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER AND
HAZARDOUS MATERIALS

FEB 1 1979

Mr. Kenneth L. Donnelly, P. E.
Chief, Engineering Division
Department of Environmental Services
Bureau of Design and Engineering
5000 Overlook Avenue, S.W.
Washington, D.C. 20032

Dear Mr. Donnelly:

Thank you for your review dated December 26, 1978, of the Category V data sheets for the District of Columbia. Your corrections have been recorded on the 1978 Combined Sewer System Data File and used in the final computation of Category V needs.

The final report, including all comments and corrections received from the States, will be forwarded to you in March 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

Illinois Environmental
Protection Agency 2200 Churchill Road, Springfield, Illinois 62706

217/782-2027

James A. Chamblee, Chief
Priorities and Needs Assessment Branch
Office of Water and Hazardous Materials
United States Environmental Protection Agency
Washington, D.C. 20460

Dear Jim:

Here are our Category V data sheets with such corrections as we were able to make. In most instances where data was missing, it is simply not available.

As I stated before, the contractors working with Illinois did a very fine job.

Sincerely,

Jim Leinicke

Jim Leinicke
Grant Administration Section
Division of Water Pollution Control

JL:jw/6041,5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 29 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Jim Leinicke
Grant Administration Section
Division of Water Pollution Control
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62706

Dear Jim:

Thank you for your review of the Category V data sheets for Illinois. The corrections which you provided have been recorded on the 1978 Combined Sewer System Data File and used in the final computation of Category V needs.

The final report, including all comments and corrections received from the States, will be forwarded to you in March 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

STATE of INDIANA

STATE BOARD OF HEALTH

AN EQUAL OPPORTUNITY EMPLOYER

1816

INDIANAPOLIS

Address Reply to:
Indiana State Board of Health
1330 West Michigan Street
Indianapolis, IN 46206

December 11, 1978

Mr. Philip H. Graham
USEPA Office of Water and Hazardous Materials
Facility Requirements Division (WH-595)
Washington, DC 20460

Re: 1978 Needs Survey Categories V and VI

Dear Mr. Graham:

Enclosed are two (2) copies of the preliminary results of a study of the use of three types of screens and terminal ponding for combined sewer overflow treatment. The final version of the report is not available at this time. The only screen recommended by the study was the Hydrasieve, which is useful primarily for the removal of gross solids and debris. Other screens required too much maintenance to be of any real use.

It is possible that a final version of this report is available from Region V; however, the consultant on this project was not aware of any report other than the one enclosed.

Please feel free to call me at (317)633-0723 if you need any additional information.

Very truly yours,

Patrick O'Connell

Patrick O'Connell
Sanitary Engineer
Water Pollution Control Division

PO/cps

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Patrick O'Connell
Sanitary Engineer
Water Pollution Control Division
Indiana State Board of Health
1330 West Michigan Street
Indianapolis, IN 46206

Dear Mr. O'Connell:

Thank you for your letter of December 11, 1978, and for your comments at our December 6, 1978, meeting in Chicago.

We have reviewed the results of the CSO screening demonstration project which you sent and have contacted the senior author. We have also reviewed other literature on screening and microscreening applications to CSO control. Our conclusions are:

1. Operating experience with microscreening has ranged from good to poor.
2. In order to operate properly, microscreens must be subject to near-constant flow rates.
3. Microscreens must also be protected from large objects (rocks, cans, etc.) in the wastestream.

The process trains for treatment levels 2 through 5, as shown on Figures 5-1 through 5-3 of the report, provide both flow attenuation by means of influent storage, which is depleted at a constant rate by pumping, and protection of the microscreen from large objects by the combined effects of storage, pumping, and coarse screening. Therefore, we believe that microscreens as utilized in the Needs Survey are a viable technology and have been retained in the final report and in the final needs estimate.

The final report, including all comments and corrections received from the States, will be forwarded to you in March, 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James. A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

STATE of INDIANA
STATE BOARD OF HEALTH
AN EQUAL OPPORTUNITY EMPLOYER

1816

INDIANAPOLIS

Address Reply to:
Indiana State Board of Health
1330 West Michigan Street
Indianapolis, IN 46206

December 27, 1978

Mr. Philip Graham
Priorities and Needs Assessment Branch (WH-547)
USEPA
401 "M" St. SW
Washington DC 20460

Re: Needs Survey, Category V and VI

Dear Mr. Graham:

Enclosed is the final set of additions and corrections to the Combined Sewer System Data File for Indiana.

If you have any questions about the enclosed material, please contact Mr. Patrick O'Connell at (317)633-0723.

Very truly yours,

T. P. Chang

T. P. Chang, Chief
Technical Support Branch
Division of Water Pollution Control

PO/cps

Enclosures

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 29 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. T. P. Chang, Chief
Technical Support Branch
Division of Water Pollution Control
Indiana State Board of Health
1330 W. Michigan Street
Indianapolis, Indiana 46206

Dear Mr. Chang:

Thank you for your review of the Category V data sheets for Indiana. Your additions and corrections transmitted on 21 December and 27 December have been recorded on the 1978 Combined Sewer System Data File and used in the final computation of Category V needs.

The final report, including all comments and corrections received from the states, will be forwarded to you in March 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

State of Kansas . . . ROBERT F. BENNETT, *Governor*

DEPARTMENT OF HEALTH AND ENVIRONMENT

DWIGHT F. METZLER, *Secretary*

Topeka, Kansas 66620

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT 1974

December 14, 1978

Mr. Phillip Graham
U.S. Environmental Protection Agency
401 M Street, S.W. (WH-595)
Washington, D.C. 20460

Dear Mr. Graham:

This is in reply to your memorandum of November 20, 1978 transmitting a preliminary report on the Combined and Storm Sewers categories of the 1978 Needs Survey.

It is very difficult to make a meaningful analysis of the adequacy of the water quality predictive system incorporated in the "Continuous Stormwater Pollution Simulation System". It is, of course, exceptionally difficult to construct a model which will reflect the many unusual circumstances which will influence water quality in urban areas encompassing a great range of climatic and geographic conditions. I would expect the data on combined sewers is better than that for urban runoff although there are certainly many complicating factors also associated with the combined sewer analysis.

Table 14-1-3 of your report indicates the following capital costs would be required to achieve the following water quality goals for Kansas:

	Current Needs	Year 2000 Needs
Aesthetics Goal	0.285	16.275
Fish & Wildlife Goal	112.000	105.000
Recreational Goal	203.000	386.000

These estimated expenditures are in sharp contrast to our water quality data and biological monitoring data which is incorporated in our 305(b) Report and which generally indicates that Kansas waters are acceptable from a fish and wildlife standpoint to the extent these waters can support balanced populations of fish and wildlife. The 305(b) Report does report a significant number of water quality standard violations attributable to nonpoint sources; however, most of these violations are attributable to natural mineralization problems characteristic of this area and to runoff from the extensive agricultural operations in the state. Additionally, many of our urban streams which would be most likely to be influenced by urban runoff quality, are without flow for extended periods of the year and may have limited fishery or recreational values only because of the discharges from sewage treatment plants. I find it difficult to accommodate these divergent concepts of relatively high corrective costs and absence of any substantive indicators of water quality or fish or wildlife problems. This is not an argument against the modeling approach which has been used but strongly suggests that great care must be taken in the interpretation of the data. I urge that you attempt to make similar order of magnitude comparison with 305(b) and 208 Reports from other states.

We have some problems with the combined sewer estimates for Kansas. We suspect the cost of meeting the fish and wildlife water quality goal is in error, which is put at about one-half of the cost of meeting the aesthetics goal in your draft report. Since the aesthetics goal is much less stringent than the fish and wildlife goal, we fail to see how the cost of meeting the former can be greater than the cost of meeting the latter. Other errors noted in the draft report pertaining to combined sewers in Kansas are as follows:

1) The cost of correction of combined sewers in the City of Topeka was put at $16.9 million in the combined sewer system data file. The consultant for the city estimates this cost to be $8.4 million.

2) The City of Kansas City alone has a preliminary estimate of $190 million for the correction of its combined sewers (please see enclosed attachment) compared to $32.6 million estimated for the whole state for the fish and wildlife water quality goal in the report. One factor for these low estimates could be the discrepant values of combined sewer acreage and population served by combined sewers entered into the model for Kansas City. The true values are 10,235 acres and 91,117 respectively.

3) We estimate the category V cost to meet the fish and wildlife water quality goal in urban areas of Kansas is $8.4 million plus $190 million for a total of $198.4 million.

I am surprised the section dealing with combined sewers does not provide any meaningful discussion of public health problems. Certainly a combined sewage overflow, which is essentially untreated human sewage, into a small stream which flows through a developed residential neighborhood park or into a shellfish producing area is highly undesirable -- perhaps dangerous -- and ought to be corrected without regard for BOD or Suspended Solids reduction. This concept seems lost in your report. The computer data for both Kansas City, Kansas and Topeka indicates that discharges occur into the Missouri and Kansas Rivers, respectively, whereas a significant portion of these flows is discharged into very small urban streams.

The modeling approach does not appear to provide a mechanism for dealing with those situations in which a combined sewer network is interposed between the treatment facility and a large suburban system of sanitary sewers. Under this arrangement, the quality of the bypassed materials should be substantially different than that in which all flows are in a combined system, i.e. a mixture of runoff and sanitary sewage. Secondly, the modeling system seems to make no provisions for incorporating the impact of industrial facilities connected to combined sewer systems or facilities, such as hospitals, which may have unusual public health significance.

Tables 13 and 14 provide very rough estimates of capital and operating costs. I think it is a mistake to show amounts with sometimes seven significant figures in view of the large assumption incorporated in the formula. In my judgment, one or two significant figures is about the most that could be justified although I assume your statiticians can provide you with a more scientific estimate of accuracy. The report should highlight the probable accuracy of the estimates.

Ultimately, it is going to be necessary to obtain factual information on combined sewer problem areas and to develop a better body of information on both the needs and costs for urban runoff problems. The former can certainly be accomplished through the Step 1 process in a relatively short period of time. The latter will require many years because of the need for obtaining additional data on water quality in urban streams and for testing some of the "pollution control theories" against water quality. I would hope the report you are preparing will place adequate emphasis on these components and will not leave decision makers with the idea the numbers in the report are highly accurate or that they are based on real data.

Sincerely yours,

Eugene Jensen

Eugene T. Jensen, Director
Bureau of Water Quality

ETJ:lm

attachment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

FEB 7 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Eugene T. Jensen, Director
Bureau of Water Quality
Department of Health and Environment
Topeka, Kansas 66620

Dear Mr. Jensen:

Thank you for your letter of December 14, 1978, reviewing our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff.

We agree that there is a degree of uncertainty in the needs estimates developed for Categories V and VI. The final report will include an additional chapter not present in the draft report, which will attempt to quantify this uncertainty. It is possible that actual Category VI needs in Kansas are less than the $418.709 million (final estimate) reported to Congress in FRD-1. However, it must be remembered that this estimate includes an allowance for future growth, and is based on full-body contact recreation objectives.

In regard to the lower cost estimates reported in the draft report for the fish and wildlife protection level than for the aesthetics protection level, the final report presents revised estimates. In the draft report pollution control technologies for the aesthetic protection level were not optimized while these control technologies were optimized for the fish and wildlife protection level.

The pollution control technologies in the final report are optimized for both the aesthetics and fish and wildlife protection levels. The aesthetics objective costs in the final report are based on an optimum combination of management practices (streetsweeping and sewer flushing) rather than on the swirl concentrator/screening system utilized in the draft report. These management practices achieve approximately the same overall pollutant removal; and, the optimum combination of management practices has a definite cost advantage.

The final needs estimates reported to Congress in FRD-1 are based on the recreation water use criteria. The reported Category V needs to meet the recreation criteria in Kansas are $204.916 million, which is very close to your estimate of $198.4 million.

With regard to the protection of small streams flowing through residential areas, costs are reported to Congress to provide pollution control from combined sewer overflows for all but a small portion of two overflow events per year.

We believe that the modeling approach utilized for the 15 site studies provides a flexible tool for investigating the interactions of an urban area and its receiving water. Each of the items that you mention in the second paragraph of page 3 of your letter influences the pollutant loading rates may require monitoring of the system in order to accurately quantify watershed pollutant yields.

Further, if certain industrial facilities, such as hospitals, are considered to be public health hazards, it would be perhaps more cost effective to pretreat or predisinfect these waste influents before discharge to the combined sewer system rather than dealing with them after discharge to the system.

The final report, including all comments and corrections received by the States, will be forwarded to you in March 1979.

I hope that my letter has answered your questions. If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

State of Maryland

DEPARTMENT OF HEALTH AND MENTAL HYGIENE
ENVIRONMENTAL HEALTH ADMINISTRATION
P.O. BOX 13387
201 WEST PRESTON STREET
BALTIMORE, MARYLAND 21203
PHONE • 301-383- 2737

NEIL SOLOMON, M.D., PH.D.
SECRETARY

DONALD H. NOREN
DIRECTOR

December 14, 1978

Mr. Philip Graham
Environmental Protection Agency
WH-595
401 M Street, SW
Washington, D. C. 20460

Dear Mr. Graham:

We have reviewed the first and second mailings of the "1978 Needs Survey, Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharge" and "1978 Needs Survey, Continous Stormwater Pollution Simulation System Users Manual" and have the following comments.

The technical expertise and methodologies indicated in these documents represent the strictest mathematical approach, which may be applicable in many states but, we feel, not applicable in this area. It would appear that the statistical has overtaken common sense because many of the decisions, which would statistically be within mathematical water quality parameters, would still be an adverse factor in the protection of public health.

One example would be the criteria utilized on page 2-17 of two untreated overflow events per year. A glance at Table A-9 on page A-19 would indicate in either season an occurrence of approximately 30 storms per year. The combined sewers in shellfish areas receive their heaviest rainfall and consequently greatest overflow during the winter months which is coincidental with the major oyster harvesting. The point that I am making or attempting to make is a consideration of fecal coliform bacteria in areas other than recreation. Nowhere within the document do I see a reference to shellfish.

Another example would be the other side of the coin - in Western Maryland where the general pH of the streams are quite low due to acid mine drainage, a problem which is not going to be solved in a short period. The effects of the low pH would have to be evaluated separately to determine the true effect of combined sewer discharge.

On the positive side, the general approach and apparent overall completeness is striking, and I am sure is a very viable document for use in achieving the objective of developing updated nationwide cost estimates.

Very truly yours,

Earl S. Quance

Earl S. Quance, P.E.
Program Administrator

ESQ:bn

cc: Mr. Kenneth Pantuck
Dr. Max Eisenberg

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Earl S. Quance, Program Administrator
Department of Health and Mental
Hygiene
Environmental Health Administration
P.O. Box 13387
201 W. Preston Street
Baltimore, MD 21203

Dear Mr. Quance:

Thank you for your review dated December 14, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff.

A consistent set of water quality criteria was applied nationwide to provide a nationally consistent estimate of Category V and VI needs. Three levels of water quality criteria were applied in the 1978 Needs Survey to show the sensitivity of the degree of protection of receiving water uses to the pollution control capital resources provided. The costs for the highest level of protection are the needs reported to Congress. This highest level of protection, called the recreation water use protection level, is also the level used in this report for the protection of shellfish and will be so noted in the final report.

Even though the recreation protection level permits two combined sewer overflow events each year, it is expected the use of storage/treatment systems would greatly reduce the amount and pollutant content of such overflow in comparison to uncontrolled overflow.

We agree that the impact of acid mine drainage should be considered when a facility is designed to control combined sewer overflow. However, it is very difficult in a nationwide survey to address all site-specific problems, which must be considered in detailed facilities plans.

The final report, including all comments and corrections received by the States, will be forwarded to you in March, 1979.

I hope that this letter has answered your questions. If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
CAPITOL COMPLEX
CARSON CITY, NEVADA 89710
TELEPHONE (702) 885-4670

December 29, 1978

Mr. Philip Graham
EPA (WH-595)
401 M Street, SW
Washington, D. C. 20460

RE: 1978 Needs Survey, Categories V and VI

Dear Mr. Graham:

I have reviewed the subject survey and have the following comments concerning it:

1) Table 13-1 13-2 and 13-3 Category V Needs; there are no Needs shown for Nevada. Several of Nevada's larger communities have sanitary sewers which carry stormwater to the treatment plant. Although these combined sewers do not discharge directly to a surface water they may cause degradation of treatment plant effluent quality by temporarily overloading the treatment plant.

We have not had ample time to estimate costs for category V Needs but we would like the Needs Survey to indicate that Nevada has Category V Needs, but the costs have yet to be determined.

2) The Category VI Needs appear to be adequate. However, we have not had ample time to make our own estimates of costs. We often wonder how the Category V and VI Needs are derived for Nevada since we have never been asked to be involved in estimating these costs during the preparation of the Category V and VI Needs Survey.

In the future, we would appreciate being invited to participate in the data gathering and cost estimating phase of the Category V and VI Needs Survey.

Yours truly,

James B. Williams J.

James B. Williams, Jr., P.E.
Construction Grants Officer

cc: Bob Rock and
Jim Thompson of
EPA Region IX

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. James B. Williams, Jr., P.E.
Construction Grants Officer
Department of Conservation and
Natural Resources
Division of Environmental Protection
Capitol Complex
Carson City. Nevada 89710

Dear Mr. Williams:

Thank you for your review dated December 29, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff (Categories V and VI).

Category V needs apply only to sewer systems which were designed to carry both sanitary wastewater and urban runoff. The problem of stormwater infiltration in sanitary sewers, to which you refer in your letter of 29 December 1978, is an infiltration/inflow problem which is estimated in Category III-A needs, "Correction of Infiltration/Inflow." A total of $1,340,000 will be reported in Category III-A for Nevada in the 1978 Needs report to Congress. Nevada has no known combined sewer systems and, therefore, no Category V needs.

The needs estimates for Categories V and VI are derived through the methodology documented in our draft report. State agencies are providing review and input data for the Combined Sewer System Data File, which is then used in part to estimate needs prior to final publication of the survey results.

The final report, including all comments and corrections received from the States, will be forwarded to your in March, 1979.

I hope that my letter has answered your questions. If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

The State of New Hampshire

COMMISSIONERS
ROBERT J. HILL, Chairman
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JAMES VAROTSIS

Water Supply and Pollution Control Commission
Prescott Park
P.O. Box 95—105 Loudon Road
Concord 03301

STAFF
WILLIAM A. HEALY, P. E.
Executive Director

RICHARD P. GROSSMAN, P. E.
Deputy Executive Director
and Chief Engineer

LINDSAY M. COLLINS, P. E.
Director of
Municipal Services

December 27, 1978

Mr. Philip Graham
Environmental Protection Agency (WH-595)
401 M Street
Washington, D.C. 20460

Subject: 1978 Needs Survey Category V - Cost Methodology for Control of Combined Sewer Overflow

Dear Mr. Graham:

Please find below our comments on Category V for the 1978 Needs Survey, as requested in your letter of November 20, 1978.

The dissolved oxygen criteria applied to the Fish and Wildlife Objective used in estimating pollution abatement control costs for Category V is contrary to the New Hampshire Water Quality Standards. New Hampshire rivers are, for the most part, cold water salmonoid type fisheries where calculated fish kills would impair ongoing improvement programs for many rivers, especially the Merrimack and Connecticut Rivers. Both the Connecticut and Merrimack Rivers are highly regulated and have established minimum flows, some below 7Q10 flows. Therefore, it is highly probable in a few river reaches that no zone of passage is available allowing fish to escape poor quality water. The minimum water quality criteria of 2 milligrams per liter dissolved oxygen should always be maintained.

The combined sewer system data file for New Hampshire should be revised to reflect the sewer separation project currently underway by the Town of Milford. The sewer separation project involves 43,000 linear feet of sewer at a cost of $2,900,000, as shown on the attached letter and combined sewer worksheet. This cost should be Code 3, Item 27 since this is the design cost (Step II) estimate.

If you have any questions or comments, please feel free to contact this office.

Sincerely,

Michael P. Donahue

Michael P. Donahue, P.E.
Director, Permits & Surveillance

MPD/bb
Enclosures

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 16 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Michael P. Donahue, P.E.
Director, Permits and Surveillance
Water Supply and Pollution Control Commission
Prescott Park
P.O. Box 95--105 London Road
Concord, New Hampshire 03301

Dear Mr. Donahue:

Thank you for your review dated December 27, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff. The criteria used for fish and wildlife protection in the 1978 Needs Survey were divergent from "Redbook," "Quality Criteria for Water," U.S. Environmental Protection Agency, July 1976, criteria and from State water quality standards. The rationale for using these divergent criteria for Categories V and VI is discussed in detail in Chapter 2 of the "Cost Methodology for Control of Combined Sewer Overflows and Stormwater Discharge," FRD-2. EPA currently is considering an aquatic life criteria comprised of a concentration to be maintained as an average during any 24-hour period and a recommended maximum concentration which should not be exceeded at any time during the 24-hour period. In the meantime, the officially recognized water quality criteria are reported in the Redbook.

The needs reported to Congress are for the recreation protection level, which provides for larger storage/treatment facilities than the fish and wildlife protection level. One nationwide set of water quality criteria were required to provide a nationally consistent estimate of Category V and VI needs. We believe the needs reported to Congress will maintain a nationwide water quality which will provide for the protection and propagation of fish, shellfish, and wildlife and provide the protection of recreation uses.

The combined sewer worksheet for the Town of Milford was changed to indicate the Step II design cost estimate for sewer separation.

The final report, including all comments and corrections received by the States, will be forwarded to you in March 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Peter A. A. Berle,
Commissioner

December 22, 1978

Mr. Philip H. Graham
Facility Requirements Division (WH 547)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Graham:

Enclosed are completed combined sewer system worksheets for the following significant non-urbanized areas together with their corrected EPA-1 forms:

363002001	Beacon (C)
364011001	Stockport (T)
364050001	Schenectady (C)
364053001	Oneonta (C)
364070001	Amsterdam (C)
366067001	Boonville (V)
367059001	Weedsport (V)
368066001	Medina (V)
369036001	Salamanca (C)

This transmittal concludes our review of the data base for combined sewers as prepared by Dames and Moore and modified by Black, Crow and Eidsness. I hope that with this information the needs in New York State can be somewhat unscrambled and more closely reflect the true situation. I cannot help but wonder, however, how accurate the data for other states may be.

Thank you for your patience and consideration. If there is anything that I can do to assist in the completion of your task, please feel free to call me at (518) 457-2570.

Sincerely,

W.F. Esmond, Jr., P.E.
Needs Survey Director
for New York State

Enclosures

cc, w/Enclosures:
Black, Crow and Eidsness
Mr. Olsen, USEPA - Region II

WFE:kf

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 29 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. W. F. Esmond, Jr., P.E.
New York State Needs Survey Director
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Dear Mr. Esmond:

Thank you for your review of the Category V data sheets for New York. Your additions and corrections transmitted on 12, 13, 15, 18, 19, 20, and 22 December 1978 have been recorded on the 1978 Combined Sewer System Data File and used in the final computation of Category V needs.

The final report, including all comments and corrections received from the states, will be forwarded to you in March 1979.

Thank you for your through review of the 1978 Needs Survey combined sewer data base. I greatly appreciate the time you and your staff took to improve the 1978 Needs Survey in New York State.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

OhioEPA

December 22, 1978

Mr. James A. Chamblee
1978 Need Survey Director
Facility Requirements Division (WH-547)
Office of Water Program Operations
U. S. EPA
401 M Street, S.W.
Washington, D.C. 20460

Attn: Philip H. Graham, Project Officer, 1978
Needs Survey for Combined Sewer
Overflows and Storm Water Discharges

Dear Mr. Chamblee:

Enclosed are data on Entities having combined sewers. The lists are as defined in Explanations (attached). These lists are not complete. However, we hope to have the data for added entities to you by December 29, 1978.

We will have comments on Categories V and VI to you by December 29, 1978.

Happy Holidays,

L. T. Hagerty

L. T. Hagerty, P.E.
Director
1978 Ohio Needs Survey

LTH:rm

Enclosure

cc: Philip Graham
Ted Horn, Region V

State of Ohio Environmental Protection Agency
Box 1049, 361 E. Broad St., Columbus, Ohio 43216 • (614) 466-8565

James A. Rhodes, Governor
Ned E. Williams, P.E., Director

OhioEPA

December 28, 1978

Mr. James A. Chamblee, 1978 Need Survey Director
Facility Requirements Division (WH-547)
Office of Water Program Operations
U.S. EPA
401 M Street, S.W.
Washington, D.C. 20460

Attention: Philip H. Graham, Project Officer, 1978
Needs Survey for Combined Sewer
Overflows and Storm Water Discharges

Dear Mr. Chamblee:

Enclosed are our comments on the "1978 Municipal Needs Survey, Categories V and VI."

1. We wish to express our appreciation for the help and cooperation we received from Philip Graham, Project Director, Washington, D.C. and Ted Horn, 1978, Needs Survey Director, Region V, U. S. EPA.

2. We, again, wish to express our displeasure with the time allotted for the "Survey". As we stated in our 1976 comments, the time is not sufficient for the detail the "Survey" deserves.

3. In our 1976 comments we pointed out the deficiencies of the USGS Gaging Stations for the 17 designated Urban Areas. As we reviewed the 1978 printout it became very evident that most of the gaging stations are not suitable for determining Water Quality requirements. It should be remembered that these stations were installed to gather information on stream flows for flood control.

4. We question the re-definition of the word optimum as stated on page 1-6 of FRD-3, "The 1976 approach did not provide for identification of optimum pollution control strategies; whereas, the approach utilized for 1978 provides

State of Ohio Environmental Protection Agency
Box 1049, 361 E. Broad St., Columbus, Ohio 43216 • (614) 466-8565

James A. Rhodes, Governor
Ned E. Williams, P.E., Director

for the selection of optimum or least-cost control alternatives." Our definition of optimum is, "the best or most favorable degree, condition, amount." We can relate optimum with "cost effective", we cannot relate it with "least-cost", which we interpret as meaning cheapest.

5. We have some questions on the following tabulations:

Category V, Storm Sewers

		Costs ($\$10^6$)		
Survey Yr.	Data from:	Aesthetics	Fish & Wildlife	Recreation
1974	Ohio EPA			3,790.331
	MCD-48C			
1976	Table 8.1	582.194		
	Table 8.2		1,207.506	
	Table 8.3			1,765.612
1978	FRD-3			
	Table 13.1	787.433		
	Table 13.2		687.043	
	Table 13.3			2,177.925

Category VI, Storm Sewers

		Costs ($\$10^6$)		
Survey Year or Projected	Data from:	Aesthetics	Wildlife	Recreation
1974	Ohio EPA			6,569.580
	MCD-48C			
1976	Table 9.1	48.631		
1990	"	864.198		
1976	Table 9.2		3,325.437	
1990	"		4,141.000	
1976	Table 9.3			3,936.619
1990	"			4,752.180
	FRD-3			
1978	Table 14.1	28.098(?)		
2000	"	33.648		
1978	Table 14.2		1,192.865	
2000	"		1,317.146	
1978	Table 14.3			3,353.954
2000	"			3,743.233

(a) Do Tables 13-1, 13-2 and 13-3, (FRD-3) have the correct headings, or are the year 2000 costs omitted?

(b) Are the figures in Table 13-1 and 13-2, (FRD-3) correct for Ohio costs? It does not appear to us that we can achieve Fish and Wildlife Water Quality for less cost than attaining Aesthic Water Quality.

(c) Are the figures, for Ohio, in Table 9.1 (MCD-48C) correct? An increase from $48,631,000 in 1976, to $864,198,000 in 1990 does not seem right. We did not notice this before since we have always planned our programs to meet Water Quality Standards, i.e., Recreation Water Quality.

(d) We have assumed that columns (1) and (2) in Table 14-1, (FRD-3) are reversed. The Current Capital Costs (Needs) should be much higher than O&M costs. Is this correct? Are the costs in columns (3) and (4) correct? We do not see how the year 2000 Capital Costs of $33,648,000 could require Annual O&M Costs of $32,692,000.

6. We agree with the criteria for Dissolved Oxygen, presented in Chapter 2., FRD-3, with one exception. We feel that the 90% criteria as stated in the last paragraph, page 2-6, is much more reasonable than the allowable one 4-hour period per year for the basis for establishment of BOD removal requirements, as stated in the next to last paragraph.

7. If the National Cost estimating is to be based on the above mentioned 4-hour minimum D.O. of 2 mg/l, any estimates of costs for Ohio will be wrong. We have proposed Water Quality Standards for an average D.O. of 5 mg/l with an allowable minimum of 4 mg/l for an eight hour period, for warmwater fisheries. D.O. for coldwater fisheries is 6 mg/l. Region V, U.S. EPA is currently insisting that we delete the 4 mg/l minimum D.O. and establish a minimum of 5 mg/l. We do not want to have Ohio's costs based on the lower D.O. criteria if we are forced by Region V to adopt and meet a higher D.O. standard. We estimate that Current Capital Costs (Needs) for Categories V and VI, based on the higher D.O. standard would be approximately $18,250,000,000. (eighteen billion).

8. The text of FRD-3 acknowledged that intermittent streams have little possibility of having fish life. However, the "Code Reference Chart and Definitions", does not have a code in Item 19 for intermittent streams or dry ditches, and there is no code in Item 21 for no fish. Ohio has many Cities and Villages located on intermittent streams or dry ditches.

9. We feel that the addition of "Non-Urbanized Area Needs" for combined sewers is an improvement over the 1976 survey. We think that a similar cost estimate should be made for stormwater needs.

Enclosed is a typed copy of our List No. II and 6 additional worksheets, (List No. IV).

If you have any questions, please contact Tom Hagerty at (614) 466-8945.

Yours very truly,

Tom Hagerty

L.T. Hagerty, P.E.
Director,
1978 Ohio Needs Survey

Ned E Williams

Ned E. Williams, P.E.
Director
Ohio Environmental Protection Agency

Enclosure

cc: Philip Graham
Ted Horn, Region V

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER AND
HAZARDOUS MATERIALS

FEB 1 6 1979

Mr. James F. McAvoy
Director, Ohio Environmental
Protection Agency
Box 1049
361 E. Broad Street
Columbus, Ohio 43216

Dear Mr. McAvoy:

We appreciate receiving Mr. William's letter of December 28, 1978, with a review of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff (Categories V and VI).

We have received Mr. Hagerty's letter of December 22, 1978, transmitting additional data and corrections for the combined sewer system data file for Ohio. These corrections have been made and the final Category V needs estimate for Ohio is based on the corrected data set.

The following are responses to the numbered comments in your letter of December 28, 1978.

2. We are already initiating the 1980 Needs Survey and are hopeful that more time will be available as a result.

3. The USGS gaging stations were used to estimate the average annual flow of a receiving water, rather than to determine water quality.

4. The sentence in question will read as follows in the final report: "The 1976 approach did not provide for identification of optimum pollution control strategies; whereas, the approach utilized for 1976 provides for the selection of the optimum mix and sizing of control alternatives."

5a. Tables 13-1, 13-2, and 13-3 (FRD-3) do have the correct heading. It is assumed that the combined sewer area will not increase; therefore; year 2000 costs are equal to present costs when measured in January, 1978 dollars.

In regard to the lower cost estimates reported in the draft report for the fish and wildlife protection level than for the aesthetics protection level, the final report presents revised estimates. In the draft report pollution control technologies for the aesthetic protection level were not optimized while these control technologies were optimized for the fish and wildlife protection level.

The pollution control technologies in the final report are optimized for both the aesthetics and fish and wildlife protection levels.

The aesthetics objective costs in the final report are based on an optimum combination of management practices (streetsweeping and sewer flushing) rather than on the swirl concentrator/screening system utilized in the draft report. The management practices achieve approximately the same overall pollutant removal, and, the optimum combination of management practices has a definite cost advantage.

5c. Table 9-1 (MCD-48C) is correct for the assumption of the 1976 Report. The assumption was that urban runoff storage capacity constructed for new urban areas, which would develop between the present time and the year 1990, would cost $0.50 per gallon, which is typical for concrete storage basins. In the 1978 Needs Survey, this assumption has been changed. It is currently assumed that urban stormwater flow control in new urban areas will be provided by earthen basins.

5d. Columns (1) and (2) in Table 14-1 (FRD-3) are not revised. The aesthetics objective needs for Category VI in existing urban areas are based on providing streetsweeping on all streets with curb and gutters once every 10 days. As a result, capital costs are lower than operation and maintenance costs because capital cost is only a small component of total streetsweeping costs. In addition, columns (3) and (4) are also correct. Category VI aesthetic needs for year 2000 apply the above criteria. In addition, stormwater detention basins are incorporated into newly constructed urban areas between the present time and the year, 2000, at a cost significantly lower than the $0.50 per gallon used in 1976, as discussed in 5c above.

6. If it is possible to eliminate all DO occurrences below 2.0 mg/l, the potential for a receiving water to support a viable fishery is greater than in a receiving water where many violations remain after combined sewer and stormwater oxygen loads are removed.

7. The criteria used for fish and wildlife protection in the 1978 Needs Survey were divergent from "Redbook," "Quality Criteria for Water," U.S. Environmental Protection Agency, July, 1976, criteria and from State water quality standards. The rationale for using these divergent criteria for Categories V and VI is discussed in detail in Chapter 2 of the "Cost Methodology for Control of Combined Sewer Overflows and Stormwater Discharge," FRD-3. EPA currently is considering an aquatic life criteria comprised of a concentration to be maintained as an average during any 24-hour period and a recommended maximum concentration which should not be exceeded at any time during the 24-hour period. In the meantime, the officially recognized water quality criteria are reported in the Redbook.

The needs reported to Congress are for the recreation protection level, which provides for larger storage/treatment facilities than the fish and wildlife protection level.

8. Item 19 of the Combined Sewer System worksheet does not include a column for intermittent streams or dry ditches because the receiving water of a combined sewer area was defined at the downstream point where CSO impacted a potential fishery. A dry stream or ditch would not be considered if the potential for fishlife did not exist.

9. Your comment to include non-urbanized area needs for Category VI in the next Needs Survey will be considered.

The final report, including all comments and corrections received by the States, will be forwarded to you in March, 1979.

I greatly appreciate Tom Hagerty's concentrated efforts to improve the 1978 Needs Survey in Ohio.

I hope that my letter has answered your questions. If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

cc: Mr. Hagerty, P.E.
Powell, Ohio 43065

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
POST OFFICE BOX 2063
HARRISBURG, PENNSYLVANIA 17120

December 26, 1978

In reply refer to:
File: 16-4.101

Mr. Philip Graham
Environmental Protection Agency (WH-595)
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Graham:

This is in response to Mr. Chamblee's request to Mr. Drawbaugh and me for comments on the 1978 Needs Survey document on Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharge. The following are our comments:

1. The criteria that are proposed (Pages 8-10) for protection of fish and aquatic life violate EPA policy ("Redbook") specifically as follows:

Parameter	Needs	"Redbook"
Dissolved Oxygen	No less than 2 mg/l as a 4 hour annual average	Not less than 5 mg/l at any time
Suspended Solids	At least 25 mg/l annual average	Not more than 25 mg/l "normally"
Lead	Dissolved lead 0.33 mg/l as a 96 hour average. This amounts to about 1/3 of the 96 hour LC 50.	Total lead not more than 1/100 of the 96 hour LC 50.
Phosphorus	Average annual lake concentration of 0.025 mg/l	Not to exceed 0.025 mg/l at any time or place in a lake.

2. The dissolved oxygen criteria of the needs would not achieve Pennsylvania standards (existing Chapter 93).

3. The lead limit of 0.33 mg/l dissolved lead would violate Pennsylvania's proposed standard for lead.

We feel that the use of criteria that are at variance with EPA policy must be justified. As far as we are concerned, the use of criteria that are at variance with Pennsylvania water quality standards are not permitted.

We thank you for providing us the opportunity to comment on this document.

Please advise us of your consideration of our comments.

Should you have a question, do not hesitate to call me at 717-787-3481.

Sincerely yours,

Brij M. Garg, Chief
Facilities Section
Division of Sewerage and Grants
Bureau of Water Quality Management

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER AND
HAZARDOUS MATERIALS

FEB 16 1979

Mr. Brij M. Garg
Chief, Facilities Section
Bureau of Water Quality Management
Department of Environmental Resources
P.O. Box 2063
Harrisburg, PA 17120

Dear Mr. Garg:

Thank you for your review dated December 26, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff.

The criteria used for fish and wildlife protection in the 1978 Needs Survey were divergent from "Redbook," "Quality Criteria for Water," U.S. Environmental Protection Agency, July, 1976, criteria and from State water quality standards. The rationale for using these divergent criteria for Categories V and VI is discussed in detail in Chapter 2 of the "Cost Methodology for Control of Combined Sewer Overflows and Stormwater Discharge," FRD-3. EPA currently is considering an aquatic life criteria comprised of a concentration to be maintained as an average during any 24-hour period and a recommended maximum concentration which should not be exceeded at any time during the 24-hour period. In the meantime, the officially recognized water quality criteria are reported in the Redbook.

The needs reported to Congress are for the recreation protection level, which provides for larger storage/treatment facilities than the fish and wildlife protection level.

The final report, including all comments and corrections received by the States, will be forwarded to you in March 1979.

I hope that my letter has answered your questions. If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
CORDELL HULL BUILDING
NASHVILLE, TENNESSEE 37219

Room 621

December 13, 1978

Mr. Philip Graham
Environmental Protection Agency (WH-595)
401 M. Street, SW
Washington, DC 20460

Dear Mr. Graham:

We have read through Parts 1 and 2 of the mailing on Category V and Category VI needs analysis and find the complex subject very adequately handled. It is apparent that a great deal of thought and preparation went into the formulation.

We notice that the cost summary in the mailings showed zero Category V needs for Tennessee. At the December 6, 1978, meeting in Chicago you told me that three combined sewer cities had recently been turned in by Dames and Moore. These were probably for Nashville, Bristol, and Chattanooga. Knoxville and Clarksville also have combined sewers. As far as we know, these are the only combined sewer cities in Tennessee.

Sincerely yours,

Donald P. Gregory

Donald P. Gregory
Environmental Engineer
Division of Water Quality Control

DPG/jg/3/2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Donald P. Gregory
Environmental Engineer
Division of Water Quality Control
Department of Public Health
Cordell Hull Building
Nashville, Tennessee 37219

Dear Mr. Gregory:

Thank you for your review dated December 13, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff (Categories V and VI). The Combined Sewer System Data File has been corrected to include the Cities of Nashville, Chattanooga, and Bristol, Tennessee. Based on the data we have for these cities, the corrected Category V needs for Tennessee as reported to Congress are $198,462,000. We have no data on Combined Sewer Systems located in Knoxville or Clarksville and Category V needs have not been estimated for these cities.

I would, appreciate receiving information regarding the combined sewers in Knoxville and Clarksville for use in future needs surveys.

The final report, including all comments and corrections received from the States, will be forwarded to you in March 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION

Montpelier, Vermont 05602

DIVISION OF ENVIRONMENTAL ENGINEERING

Department of Fish and Game
Department of Forests, Parks, and Recreation
Department of Water Resources
Environmental Board
Division of Environmental Engineering
Division of Environmental Protection
Natural Resources Conservation Council

December 4, 1978

Mr. Phillip Graham
Environmental Protection Agency (WH-595)
401 M. Street, SW
Washington, D.C. 20460

Re: Category V and VI Needs
State of Vermont

Dear Mr. Graham:

This office has reviewed the draft report on needs in Category V (combined sewer overflows) and Category VI (urban stormwater runoff) prepared by Dames & Moore, Inc., and CH2M HILL.

Category V; we are in agreement with the figures as presented in the draft report.

Category VI; As in the 1976 survey, the needs in this category were based on urbanized areas, as designated by the U.S. Bureau of Census. Due to the lack of urbanized areas, once again the State needs in this category have been calculated as being zero. We submit that, to use this criteria for a state such as Vermont, is totally inaccurate. The water quality needs do not disappear when urbanized areas do not exist. It is the State's opinion that there are several large communities where stormwater discharges can degrade water quality, and, under present laws, corrective action will have to be undertaken under this category at some future time. The following is a list of the communities with their respective (low side) control costs.

Community	*Feet Connecting Storm Sewer @ $80.00/lf*	*Sedimentation Basin(s)*	*Total Costs*
Burlington	*$ 31,680*	*4 @ 397,600*	*$ 4,124,800*
St.Johnsbury	*15,840*	*2 @ 397,600*	*2,062,400*
Newport City	*15,840*	*1 plus pump station*	*1,835,200*
Rutland City	*23,760*	*4 @ 397,600*	*3,491,200*
Bennington	*21,120*	*3 @ 397,600*	*2,882,400*
St. Albans	*21,120*	*2 @ 397,600*	*2,484,800*
Windsor	*13,200*	*1 @ 397,600*	*1,453,600*
Springfield	*13,200*	*1 plus pump station*	*1,624,000*
Hartford	*21,120*	*2 @ 397,600*	*2,484,800*
Brattleboro	*10,560*	*2 @ 397,600*	*1,640,000*

Community	Feet Connecting Storm Sewer @ $80.00/lf	Sedimentation Basin (s)	Total Costs
Winooski	$ 10,560	1 @ 397,600	$ 1,242,400
Colchester F.D. #1	26,400	1 @ 227,200	2,339,200
Shelburne F.D. #1&2	21,120	1 @ 227,200	1,916,800
So. Burlington (Bartletts Bay)	10,560	1 @ 397,600	1,242,400
		TOTAL =	$30,824,000

Note: The above figures are based on Jan. 1, 1978 dollars.

These figures were generated based on a map determination of interceptor footage required and a determination of the number of treatment facilities necessary to reasonably treat the discharges. As the above figures clearly represent the actual needs for the State of Vermont, we submit that these figures should be included in the needs estimate for Category VII for the State of Vermont.

Sincerely,

Reginald A. LaRosa, P.E., Director
Division of Environmental Engineering

RAL/DB/lg

cc: Charles Bishop, EPA
Ralph Caruos, P.E., EPA
Alfred Pelequin, N.E. Interstate Water Pollution Control Commission
Secretary Brendan Whittaker, AEC

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Reginald A. LaRosa, P.E.
Director, Division of Environmental
Engineering
Agency of Environmental Conservation
Montpelier, VT 05602

Dear Mr. LaRosa:

Thank you for your review dated December 4, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff (Categories V and VI).

Your comments requesting the inclusion of communities other than urbanized areas for Category VI needs were voiced by Vermont and other States in the 1976 Needs Survey. Regulations for the application of the NPDES Program to separate storm sewers were published in the Federal Register on March 18, 1976. This document and the permit program that it established were utilized to determine the areas requiring Category VI needs.

The regulations defined the term "separate storm sewer" as "a conveyance or a system of conveyances. . .located in an urbanized area and primarily operated for the purpose of collecting and conveying stormwater runoff." The permit-issuing authority may designate other storm sewers as being significant contributors of pollution and thus subject to these regulations. In the absence of specific designations, stormwater needs are estimated for census-defined urbanized areas only. Your estimate of $30,824,000 for Category VI needs outside of urbanized areas will be submitted to Congress as a separate State estimate.

The NPDES rules applicable to separate storm sewers are currently being revised; the proposed rules are reported in the Federal Register of August 21, 1978, Part II. The storm sewer definition restriction to urbanized areas has been removed in these proposed rules. If these rules become final as proposed, the scope of the 1980 Category VI Needs Survey will include pollution control costs for "concentrated storm sewers" which are subject to the individual permit program.

The final report, including all comments and corrections received from the States, will be forwarded to you in March, 1979.

If I may be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

1889

STATE OF
WASHINGTON

Dixy Lee Ray
Governor

DEPARTMENT OF ECOLOGY
Olympia, Washington 98504 206/753-2240

Wilbur G. Hallauer, Director

December 21, 1978

Mr. James Chamblee
Chief, "Need" Assessment Section
Facility Requirements Branch (WH-547)
401 M Street S.W.
Washington D.C. 20460

Dear Mr. Chamblee:

I was provided a brief of your December 6th meeting regarding the combined sewer needs survey by Mr. Frank Monahan of our staff. It concerned me to learn that the data base being used to calculate the needs of the Seattle-Metro and Everett areas contained significant errors.

To correct this data we have requested from each entity official data for your use. The Seattle information is enclosed for your use and the Everett material will be sent under separate cover. The source of this data is recently completed facility plans making it the most reliable.

We have maintained that since 60 percent of Seattle's system has separated storm and sanitary sewers, the overflows from separated areas should be considered as I/I problems and reported under category III-A. Since EPA has chosen not to agree with this determination, I urge you to see that the combined sewer overflow needs are properly addressed in category V.

Without full consideration of the combined sewer overflow needs in our state, particularly the major metropolitan area needs, there will be a decline in Washington State's proportion of the national needs and subsequent grant allocations. This would seriously jeopardize projects for which facility planning and design have been completed over the past several years.

If more data is needed, please contact me as soon as possible. I would like to be advised of the changes in our data base when you have completed them.

Yours truly,

Wilbur G. Hallauer

WGH:nd

cc: Senator Warren G. Magnuson
Thomas Jorling, Assistant Administrator, EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Wilbur G. Hallauer, Director
Department of Ecology
Olympia, WA 98504

Dear Mr. Hallauer:

Thank you for your letter of December 21, 1978, correcting the Combined Sewer System Data File for Seattle. A combined sewer area of 32,000 acres with a population of 330,000 was recorded in the data file, per Mr. Wiatrak's letter of December 12, 1978. These data, together with information previously available, result in a total combined sewer area of 38,978 acres serving 377,980 persons for the Seattle urbanized area. These figures were used in the final Category V needs estimate.

The final report, including all comments and corrections received from the States, will be forwarded to you in March, 1979.

If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

NICHOLAS J. MELAS
PRESIDENT

Hugh H. McMillan
General Superintendent
751-5722

THE
METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO
100 EAST ERIE ST., CHICAGO, ILLINOIS 60611 . . . 751-5600

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December 21, 1978

Mr. James A. Chamblee
Needs Survey Director
U.S. Environmental Protection Agency
401 M. Street, S.W.
Washington, D.C. 20460

SUBJECT: 1978 Needs Survey, Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharges (Categories V and VI)

Dear Mr. Chamblee:

The Metropolitan Sanitary District of Greater Chicago has reviewed the subject draft report. With respect to the control of pollution from combined sewer overflows and urban stormwater runoff, the report attempts to provide a uniform set of receiving water quality criteria, a comprehensive set of treatment technologies and a uniform analysis methodology to estimate the cost of combined sewer overflow and urban stormwater pollution control in the United States. While conceptually commendable, this approach, as documented in the subject report, falls far short of the effort necessary to accurately assess the needs that are being addressed. It is of the utmost concern to the Sanitary District that while the report's considerable volume implies a rigorous and technically complex analytical foundation, national needs have been extrapolated from a fundamentally deficient and simplistic assessment of criteria and a technically crude theoretical evaluation of 15 site specific areas. Site specific studies concerning combined sewer overflow and urban stormwater pollution control, such as the Sanitary District's, have not been utilized, even though available and procured with resources and the cooperation of the USEPA.

The following comments are provided to substantiate the concern of the Sanitary District that the findings of this report should be strongly qualified as to the report's deficiencies.

Receiving Water Quality Objectives:

Of the three receiving water quality objectives delineated, aesthetics, fish and wildlife, and recreation, only the recreation objective appears to reflect the goals and policy of the Federal Water Pollution Control Act. Additionally, only the recreational objective is compatible with the Water Quality Regulations of the State of Illinois. As a consequence, the evolution of the two sub-standard objectives are of concern to the Sanitary District. It is recommended that these sub-standard objectives be clearly defined as not addressing the goals of the Federal Water Pollution Control Act.

SUBJECT: 1978 Needs Survey, Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharges (Categories V and VI)

Aesthetics Objective:

Page 13-14 of the report recognizes the arbitrary character of the aesthetics objective with the statement "...the arbitrary, technology-based aesthetics objective;..." It does not appear that this significant qualification of the aesthetics objective is contained elsewhere within the report. It is the view of the Sanitary District that the aesthetics objective is misnamed. It is based upon an unproven technology (swirl concentrators and/or screens at combined sewer overflow points), and it is highly doubtful that an acceptable aesthetic level would be produced from the application of such technologies. At best, such technologies would still transmit to a receiving water significant portions of the odorous and obnoxious raw sewage contained in the combined sewer overflows. As a consequence, it is suggested that the aesthetics objective be more appropriately named to reflect, that while some pollution load will be removed, the impact on the receiving stream will be basically unchanged from an aesthetic perspective.

Fish and Wildlife Objective:

The parameters utilized to analyze the fish and wildlife objective reflect a glaring, significant omission. While nitrogenous BOD is considered with respect to its effect on dissolved oxygen levels, the toxicity of ammonia to fish and wildlife is totally ignored. The Illinois Pollution Control Board has established an ammonia stream quality standard of 1.5 mg/l for the waters of Illinois. This standard is predicated on the toxic characteristics of ammonia at nominal ranges of stream pH. A comprehensive analysis of data available to the Sanitary District for combined sewer overflows to its waterways indicates that combined sewer overflow ammonia concentrations exceed 1.5 mg/l approximately 70% of the time. Average overflow concentrations as high as 13 mg/l have been measured. As high ammonia concentrations are typical of domestic sanitary wastes, no non-structural alternatives are available for its elimination from combined sewer overflows. It is, therefore, strongly recommended that the needs assessment be revised to include the impacts of ammonia toxicity.

Technologies for Combined Sewer Overflow Control:

Chapter 3 of the report delineates a number of pollution control technologies for the control of combined sewer overflow (CSO) and urban stormwater runoff pollution. An element missing from this presentation is a comprehensive analysis of these technologies or systems of these technologies compared against uniform standards. Swirl concentrators are not equivalent to off-line storage followed by complete treatment. Furthermore, source controls for the reduction of nonpoint urban stormwater pollution loadings are not compatible with technologies for the elimination of the raw sewage pollution loadings associated with combined sewer overflows.

SUBJECT: 1978 Needs Survey, Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharges (Categories V and VI)

In addition, this section does not address the peripheral problems that may be associated with a number of the technologies delineated. In-line storage and flow concentrators can seriously aggravate flooding in a combined sewer area. It is recommended that the relative merits of the proposed technologies be defined, and their constraints be further documented.

The report points out (page 3-9) that cost data for treating combined sewer overflows and urban stormwater runoff using biological systems were not considered in the needs estimate, since, as the report states, the application of an integrated wet/dry weather biological treatment facility is extremely site specific. The District is providing a system of surface collecting structures and conveyance tunnels which will intercept and transport the captured combined sewer overflows (CSO) to large storage reservoirs. Subsequently, after the storm has subsided, the CSO will be pumped to existing wastewater treatment plants for purification and discharge to the waterways.

There are several advantages which this system provides. First of all, shock hydraulic loads will not be imposed on the treatment facility, consequently pollutant removal efficiencies should not be impaired. Secondly, by integrating controlled wet and dry weather flows over a longer timeframe, optimum utilization of treatment plant capacity is possible. Thus, a treatment capacity of 1.5 times dry weather flow will be adequate rather than the 2.5 times dry weather flow generally specified in the NPDES permits for combined sewer areas by the USEPA. Further, pollution of the waterways caused by CSO will be almost completely eliminated and flooding of low-lying areas will be considerably reduced. Moreover, there are significantly lower capital costs involved in utilizing an existing biological treatment plant in order to achieve these objectives than other treatment alternatives discussed. Therefore, we believe that the applicability of dual biological treatment facilities in treating CSO and stormwater has national significance, thus should be reconsidered and appropriate cost data supplied.

Receiving Water Response Model:

The application of the receiving water response model provides, at best, a crude estimate of needs and these may be inaccurate by orders of magnitude of the needs assessed. As examples of the inaccuracies which have been introduced by this model's application for the waterways of the Sanitary District, the following are submitted:

1. Nitrogenous Oxygen Demand. Studies of the Sanitary District's basic canal and river system have indicated that nitrification within the system is negligible. The characteristics of the canal and river system, the upstream input of relatively ammonia free Lake Michigan water, the anaerobic state of benthal deposits, and major inputs of chlorinated effluents all act to inhibit nitrification within the waterway systems. The nitrogenous oxygen demand load has been found to be exerted far downstream from the urban area in the Illinois River. The model assumes the nitrogenous oxygen demand load is exerted within the urban area.

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2. Sediment Oxygen Demand. The Sanitary District's basic canal and river system exhibits low flow velocities through large channelized sections. The system characterizes a very efficient linear settling tank. As a consequence, sediment oxygen demands are extremely high. These oxygen demands have been measured, and their loading is on the same order of magnitude as the treatment plant loadings to the system. The estimated benthic demand values utilized in the model grossly underestimate the sediment oxygen demand of the Sanitary District's waterway system.

3. Upstream Water Quality. The headwaters of the Sanitary District's canal and river system is Lake Michigan. The quality of Lake Michigan water is extremely high. Data presented in the report for Chicago appeared to indicate an upstream water quality suspended solids concentration of 88 mg/l. This is a gross overestimate of the suspended solids concentration of Lake Michigan water (6 to 8 mg/l in the Chicago area).

4. Dissolved Oxygen Concentration. While dissolved oxygen was used as a prime indicator to assess needs for combined sewer overflow control, the application of the model to assess this parameter is somewhat suspect. Modelling exercises on the Sanitary District's basic waterways systems indicate that during periods of combined sewer overflows, oxygen rich stormwater, coupled with relatively high flow velocities within the waterway system, tend to negate the deoxygenating effects of introduced pollution loads. Critical periods for maintenance of adequate dissolved oxygen within the waterway are characterized by warm, dry weather. The combination of warm water, sewage treatment plant effluents, and high sediment oxygen demands (the benthic material is replenished by combined sewer overflows occurring approximately every fourth day) defines a maximum loading situation.

It is of interest to note that the Sanitary District is constructing an instream aeration system for its waterways. The first prototype station was operating during the summer of 1978. While the instream aeration system will be able to positively maintain adequate dissolved oxygen concentrations through the waterway, this instream aeration system will not alleviate any portion of the pollution loadings on these waterways, nor will the system accelerate the stabilization of carbonaceous or nitrogenous oxygen demanding substances. The dichotomy presented by the potential availability of an oxygen rich receiving stream which is grossly polluted, underscores the qualifications which must be imposed on utilizing dissolved oxygen as a prime indicator to assess combined sewer overflow needs.

5. Model Utilization, Calibration and Verification. The conceptual, theoretical, and empirical sophistication of the continuous modelling system utilized in the report does not discount the fact that its application on a national scale affords only a crude estimate of combined sewer overflow and

urban stormwater needs. The assumption and utilization of the assimilative capacities of streams and the site specific nature of combined sewer overflow and stormwater needs demand a more thorough and site specific study. From the report, the receiving water flow for New York appears to be 40.2 cfs at suspended solids concentration of 20 mg/l. As needs are a function of the quality of receiving water flow, New York's needs would be estimated as greater than Chicago's. The 40.2 cfs flow, however, appears to be rather low. Chicago's receiving water flow is estimated at 568 cfs, which is approximately the direct diversion flow from Lake Michigan through the District's canal system. However, the suspended solids concentration attributed to this flow appears to ignore that the water source is Lake Michigan. The receiving water course analyzed for Milwaukee, Wisconsin appears to be the Milwaukee River, however, the immediate and ultimate receiving water is Lake Michigan.

The report indicates that the model has been calibrated for two urban areas. Considering the comprehensive national utilization of the model, the extent of calibration is totally inadequate. In addition, no evidence is presented to indicate that the model was verified for any of the urban areas analyzed. The absence of a verification exercise allows no assignment of credibility to the model. The necessity for the verification of mathematical models is recommended by USEPA guidance on this subject and is generally accepted amongst experts in the field (i.e. USEPA Areawide Assessment Procedures Manual, July 1976; USEPA Urban Stormwater Management and Technology Update and Users Guide, September 1977).

Also, investigators have not shown or proven that transfer of nonpoint source water quality data from one region to another can be accomplished accurately. When transferring such data, such factors as varying climatic and meteorological conditions, topography, hydraulic characteristics of land surface and waterways, and land use activities on a watershed must be considered. There are no accepted criteria or methodologies for transfer of such data. In other words, there is no real substitute for observed data on the watersheds to be analyzed.

The report should, in its preamble specifically delineate that an unverified, inadequately calibrated model was utilized to perform the needs analysis. The readers may then be aware of the limitations of the needs estimated.

Report Conclusions:

An indicator of the reasonableness of the estimated needs is the comparison of needs generated by a site specific detailed analysis to those estimated by the report's methodology. The Sanitary District has analyzed the combined sewer overflow problem for its area in detail. Over ten years of study is involved and a number of site specific calibrated and verified receiving water quality models were utilized. Under the combined sewer recreational water quality objective, the District's remaining needs are

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estimated at $2.1 billion. This figure is higher than the $1.8 billion estimate attributed to the entire State of Illinois, and as a consequence, the $1.8 billion figure is obviously underestimated.

In summary, the emphasis of the report on small scale technologies, which are highly doubtful as to acceptable performance, and water quality objectives, which neither are intended to meet the national goals nor State of Illinois objectives, is misleading to the casual reader. The report must place these items in proper perspective. A major oversight of the report is its failure to consider the adverse toxic impacts of ammonia nitrogen introduced into receiving streams through combined sewer overflows.

Attached are documents further detailing the toxic effects of ammonia nitrogen, additional detailed comments and questions concerning the report, and the District's comments of September 20, 1978 to the USEPA "Report to Congress on Combined Sewer Overflows," portions of which apply to the combined sewer overflow aspects of this "Needs" study.

Very truly yours,

HMcMillan

Hugh H. McMillan
General Superintendent

HHM:FCN:WM:ag

w/attachments

cc: Mr. Phillip Graham, USEPA

DETAIL ADVERSE TOXIC IMPACTS OF AMMONIA

Nitrogen is known to occur in organic and ammonium forms in CSO. The concentration of these forms as they occur in CSO is highly variable and depends on several factors such as land use practices, industry prevalence, storm events, their duration and interval between storms, dilution rate of sewage by urban runoff, etc. The concentration of organic nitrogen in CSO was reported to be in the range of about 3 to 10 mg/l, and NH_4-N in the range of 1 to 3 mg/l in a study conducted at Bucyrus,Ohio,the Sandusky River. Higher concentrations than these may occur in CSO if it carries excessive quantities of suspended solids which originated from sewage or other nitrogenous materials. In a separate study conducted to evaluate the mineralization of organic nitrogen in urban stormwater runoff of Madison, Wisconsin, it was found that more than 50% of the total nitrogen could be mineralized and be made available for algal uptake. Although extensive information on the nitrogen content of CSO's is lacking, it is conceivable that nitrogen present in CSO's has the potential to cause adverse effects either in its indigenous or mineralized state.

Ammonium and nitrate nitrogen species are known to cause biostimulation at a concentration of about 0.3 mg N/l. The nitrogen concentration that is available in CSO's may generally exceed this critical concentration by several fold and cause algal blooms in receiving waters when appropriate environmental conditions such as the presence of phosphorus, carbon dioxide, sunlight, and optimum temperature prevail. Even if inorganic nitrogen is not present above the critical concentration of nitrogen known to cause biostimulation, it may be formed eventually due to mineralization of the organic nitrogen contained in CSO.

Ammonia in its undissociated form is known to adversely affect fishlife at as low a concentration as 0.01 mg/l. High concentrations of undissociated ammonia may occur if the pH of CSO is above a pH of 9.5.

When chlorination is practiced for the disinfection of water and wastewater, its efficacy is impaired if NH_4-N is present in them because of the formation of chloramines. Chloramines are not as effective as free chlorine for disinfection. Approximately 8 mg Cl_2/l is consumed for 1 mg NH_4-N/l before free residual chlorine results. If other chlorine demanding substances such as organics and reduced compounds, are present, the requirement of Cl_2 is even greater.

Another adverse effect that the CSO's might exert is oxygen depletion in receiving waters. This is not only due to the oxygen demand exerted by carbonaceous matter but also due to the oxygen demand exerted by NH_4-N contained in CSO. Under appropriate environmental conditions, nitrifying organisms oxidize NH_4-N to NO_3- and in doing so exert an oxygen demand of about 5 mg/l for every mg NH_4-N/l oxidized. Depending on the potential for mineralization of organic nitrogen and subsequent oxidation of the NH_4-N formed and that of the NH_4-N present initially, the oxygen depletion in receiving waters may be significant. The resulting sag in dissolved oxygen due to this depletion may have an adverse effect both in terms of fish populations, esthetics, and any intrinsic recreational value.

The potential adverse health effects of ammonia have been evaluated by the Illinois Pollution Control Board and as a consequence, the Board has set an ammonia limit of 1.5 mg/l for General Use waters. Thus, the potential adverse toxicity of ammonia should be evaluated in the "Needs" report.

ADDITIONAL COMMENTS AND QUESTIONS

How were the water quality data used for identifying receiving waters, and for determining pollutant loadings from U.S. cities listed in the report? Specific information requested are sampling methods, frequency of sampling, sampling locations, chemical procedures,etc.

How were the actual pollutant loadings determined for the fifteen watersheds transferred to other areas of the country? The methodology is not identified.

It is stated on page 1-2 and 1-3 of the report that a uniform set of assumptions, criteria, and methods were used in order to develop the nationwide estimates. Because of the variable nature of stormwater quality data, it is our opinion that it is not possible to assume uniform conditions.

NICHOLAS J. MELAS
PRESIDENT

BART T. LYNAM
GENERAL SUPERINTENDENT

THE
METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO
100 EAST ERIE ST., CHICAGO, ILLINOIS 60611 . . . 751-5600

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September 20, 1978

Mr. Michael B. Cook, Acting Director
Facility Requirements Division (WH-547)
U. S. Environmental Protection Agency
401 M. Street, S.W.
Washington, D.C. 20460

Subject: Report to Congress on Combined Sewer Overflows

Dear Mr. Cook:

The Metropolitan Sanitary District (MSD) has reviewed subject draft report and offers the following comments:

1) We recommend that a qualitative description be given of the pollution which results from combined sewer overflows. Combined sewer overflows cannot be equitably or usefully compared to sewage treatment plant effluents as has been done in the subject report.

Sewage treatment plant effluents are generally disinfected, and the organic matter contained in sewage treatment plant effluents is finely dispersed and relatively stable with respect to deoxygenating potential.

Combined sewer overflows contain raw sewage which is highly unstable, putrescent, carriers of disease organisms, malodorous, and visually repugnant. The combined sewer overflows are discontinuous, and impact the water during storm events at a frequency of approximately once every four days. During combined sewer overflows, heavier particulate organic material settle to the bottom of the waterway and contribute to a benthic load which detrimentally impacts the waterway even during dry weather periods. Floatable and soluble organic material impact the waterway with a shock pollution loading which totally negates any fishable to swimmable goals. The impact of a large combined sewer overflow event on any viable aquatic biota element in the waterway could be described as catastrophic.

In the MSD area, virtually 100% of the visual pollution in river and streams comes from combined sewer overflows and this violates the primary requirement of PL 92-500.

Also, in many areas, combined sewer overflows constitute a major source of industrial waste discharges to waterways. Such industrial wastes may be highly toxic or otherwise harmful to the ecology of the receiving waters and to potential users of the waters.

In addition, the report analyzes the relative contribution of 5 pollution parameters by combined sewer overflows, treatment plants and urban runoff. The pollution parameters are listed on page 17 of the report. We believe, since one of the main purposes of reducing pollution is protection of health, it would be beneficial to consider the amount of E-coli contributed by the various pollution sources. E-coli are considered an indicator organism or a measure of the potential ability of a pollution source to spread disease. Even a casual analysis would indicate that combined sewer overflow is considerably greater in E-coli count than plant effluent. The addition of this parameter would aid in putting the combined sewer overflow problem in proper perspective.

2) In order to determine cost, it is noted that the report (pages 4, 41 & 42) uses an economic life of 50 years for collection systems, 10 years for mechanical equipment and 20 years for treatment plants. We disagree with these life estimates, since it is our opinion that the rock tunnel systems presently being constructed to solve the combined sewer overflow problems in the MSD area will have an economic life of at least 500 years, and we estimate major mechanical equipment and plants will last approximately twice as long as assumed in the report. We not only disagree with the economic life estimates stated in the report, but also the conclusion that construction "should be realistically viewed as continuous."

3) The report discusses so-called alternatives; however, it is apparent that each of the alternatives do not meet any established goal. As an example, storage-treatment systems will intercept combined sewer overflows, convey the flows to a storage vessel and then treat all flows so that discharges to the waterways can meet waterway quality requirements. By providing storage we have determined that we can make better use of treatment plant capacity. We plan to expand our treatment plants to a size equal to 1-1/2 times average dry weather flow instead of the 2-1/2 times average dry weather flow requirement of NPDES Permits for combined sewer areas. By maintaining a size of 1-1/2 times dry weather flow we will save approximately $1 billion in capital cost on the treatment plant expansions. No other alternative provides this opportunity. Therefore, street sweeping, sewer flushing or sewer separation cannot be regarded as alternatives which are equal to the storage treatment system. It is recommended, therefore, that the term "alternative" not be used because it conveys a false impression.

4) We have reviewed the details of the street sweeping, sewer flushing and sewer separation systems and concur with the conclusion that these three systems have severe limitations. We believe the report should emphasize the limitations of each of the systems in the Executive Summary and not give them credence by calling them alternatives.

5) The report does place all cities----large or small----in the same category. We believe this is an error because major cities such as Chicago, Detroit, New York and Philadelphia have combined sewer overflow problems with tributary areas in excess of 2,000 acres

and, therefore, the discussion of so-called alternatives should be separate and distinct from the small communities.

6) The nationwide costs of $21 billion represented as needed for control of combined sewer overflows is not properly placed in perspective. The figure based on generalized methodology developed in the needs survey does not reflect real costs already contained in facility plan reports. As an example, the figure listed for Illinois is approximately $3 billion in Table 4.1, whereas the MSD Facility Plan cost for TARP Phase I being funded by the USEPA totals $1.9 billion of which $0.7 billion is under construction. Since the MSD area contains most of the combined sewered area in Illinois, the $3 billion figure appears grossly high. If this is true in other areas, then the $21 billion number is grossly misleading.

Attached are copies of and comments on selected pages of the subject draft report on which we are making suggested revisions in order to reflect the above comments.

In closing, we do concur in the recommendation that funding Alternative #1 be pursued as stated in our letter of July 17, 1978. Alternative #1 states, in part: "Construction grant funds will be allocated to each State under the present allocation formula."

We believe that this system will provide all parties to solve the combined sewer overflow problem in a timely manner.

Thank you for giving us this opportunity to review the draft report.

If you have any questions pertaining to our comments or would like to meet on this subject, please feel free to contact this office.

Sincerely,

Bart T. Lynam
General Superintendent

BTL:FCN:FED:jn

Attachment (8 pages)

cc: John T. Rhett

Suggested Changes (Indicated in Capital Letters)

Page 1 of 8

Executive Summary
-Page 9-

investment in additional research would likely yield substantial net savings to the public. For example, if additional research resulted in development of technologies which are 5% more efficient than technologies available today, $1 billion could be saved.

This report presents an analysis of the unit removal costs expressed in dollars per pound of BOD_5 removed from the receiving water for a combined sewer watershed. IT SHOULD BE NOTED THAT FOR EXCEPTIONALLY LARGE OR OTHERWISE UNUSUAL WATERSHEDS, THE COSTS AS REPORTED HERE MAY NOT BE APPLICABLE. THESE CASES NEED TO BE ADDRESSED INDIVIDUALLY. Unit removal costs are developed for nonstructural or low-structural control alternatives such as street sweeping, catch basin cleaning, and sewer flushing as well as for structural or capital intensive controls which involve storage and/or treatment. The results of this analysis for nonstructural or low-structural controls are:

1. Streetsweeping, IF PERFORMED FREQUENTLY, can be used to remove FROM 2% TO 11% of the watershed BOD_5 load at a cost of from $3 to $12 per pound of BOD_5 removed. THUS STREETSWEEPING HAS LITTLE POTENTIAL TO IMPROVE WATER QUALITY PARTICULARLY IN LARGE AREAS BECAUSE OF THE SMALL REMOVAL PERCENTAGE.
2. Catch basin cleaning is not a viable alternative because of low removal and high cost.
3. A CONTINUOUS sewer flushing PROGRAM can be used to remove from 18% to 32% of the watershed BOD_5 load at a cost of from $.94 to approximately $4 per pound of BOD_5 removed. THE ABOVE FIGURES ARE FOR VERY SMALL DRAINAGE AREAS. SEWER FLUSHING AS A SOLUTION IN LARGER AREAS IS NOT A VIABLE ALTERNATIVE BECAUSE OF THE LARGE SIZES, LONG SEWER LENGTHS AND TREMENDOUS QUANTITIES OF WATER NEEDED EVEN TO ACHIEVE AN 18% REMOVAL.

4. Swirl concentrators/regulators can be used to remove up to 56% of the watershed BOD_5 load at a cost of from \$2.30 to \$4 per pound of BOD_5 removed. IN MOST LARGE AREAS, THIS PERCENT REMOVAL IS NOT SUFFICIENT NOR ARE THEY VIABLE BECAUSE OF SPACE RESTRAINTS AND THEY AGGRAVATE FLOOD PROBLEMS.

The cost and effectiveness of storage/treatment systems depend to a large extent upon the size of the area served. Storage/treatment systems become more cost-effective as the area served by a given facility increases. For a small watershed of 100 acres or less, sewer separations may be a cost-effective control alternative. Sewer separation with subsequent treatment at a secondary WWTP will remove approximately 65% of the total watershed BOD_5 load at a unit cost of approximately \$24 per pound removed. For watersheds greater than about 200 acres, storage/treatment systems will become more cost effective than sewer separation. The relationship between facility size percentage of BOD removal and unit cost is illustrated on Figure 7-1 of this report.

The following comments pertain to storage/treatment systems.

1. In-line storage including real time control (RTC) of the collection system is a viable alternative if the existing collection system has a large interceptor storage capacity. In-line storage with subsequent treatment at a secondary WWTP will remove up to 45% (possibly more in collection systems not yet investigated) of the watershed BOD_5 load at a cost of from \$1.25 to \$4 per pound of BOD_5 removed.

2. Off-line storage in a highly developed urban area is expensive. In many cases, covered concrete storage basins will be required to permit dual land use. Therefore, economic optimization of all proposed storage/treatment systems should be required before construction funds are granted.
3. Storage/treatment systems are the only technologically viable alternative for removal of more than about 65% of the total annual watershed BOD_5 load.
4. For large watersheds greater than 2,000 acres in size, the optimum storage/treatment system can be used to remove from 30% to 80% of the watershed BOD_5 load at a cost of from \$3 to \$4 per pound of BOD_5 removed.
5. FOR EXTREMELY LARGE WATERSHEDS IN THE RANGE OF 10^5 ACRES, STORAGE TREATMENT IS THE ONLY OPTION CAPABLE OF ADDRESSING THE ENORMITY OF THE PROBLEM ON A COST-EFFECTIVE BASIS, WITH NON-STRUCTURAL SOLUTIONS BECOMING HIGHLY UNREALISTIC BOTH FROM A COST STANDPOINT AND FROM THE AMOUNT OF POLLUTION THEY COULD EFFECTIVELY REMOVE.

The reader should remember that the discussions of pollutant loadings and technological alternatives presented in this Executive Summary and in the main body of the report represents a summary of our understanding of the CSO pollution problem as it exists today and that this understanding is everchanging. Much information has been developed in the last few years, and it is probable that much more will be developed in the future.

INSERT

STREET CLEANING DISADVANTAGES

APPENDIX C (OUR PAGE 143)

4. to provide more than minimal benefits, sweeping would have to be almost continual.
5. frequent parking restrictions necessary for continual cleaning will meet with adverse public acceptance resulting in non-compliance and drastically reduced effectiveness.
6. not very effective in areas with streets in poor condition or with cobblestone streets.
7. seasonal measure; can only be employed in fair weather months.
8. effectiveness very dependent upon factors over which you have no control, i.e., when it rains, before or after sweeping.

INSERT

BEFORE LIST OF ADVANTAGES
COMBINED SEWER FLUSHING

APPENDIX C (OUR PAGE 144)

4 (A)

Sewer flushing demonstration projects have only been performed on systems with sewer sizes in the range of 12"-15". In the Metropolitan Sanitary District area 53 communities have combined sewers with a length approximately 25% or 1,715 miles are between 24" in diameter and 20' in diameter. The flushing of such sewers is totally impractical. Flushing of large sewers (in addition to flushing the network of smaller tributary sewers) would require fleets of tank trucks, connections to hydrants where the water supply mains and pressures are adequate, or construction of sluice gate installations with telemetry controls throughout the system. All of these methods, when applied to large size sewers over extensive areas, are prohibitive as to cost and disruption of water supply systems and/or traffic. It is further noted that the control devices at the interceptor sewers are not designed to capture the volume of water necessary to have an effective flush without overflow to the waterways or are the interceptors themselves large enough to convey the capacity of the combined sewers, being designed to carry dry weather or sanitary equivalent flows. The flushing of sewers, in order to be effective, would have to be performed prior to every significant rain or snowmelt event. Indeed the only practical method of regular flushing action, to obtain the degree of pollution control claimed in the report, is by the utilization of the rainfall itself to flush the sewers and to collect and temporarily store this water after each rainfall. This is what is to be done in the Tunnel and Reservoir system (TARP).

INSERT
THIRD PARAGRAPH UNDER "SWIRL AND HELICAL CONCENTRATORS"
APPENDIX C (OUR PAGE 150)

It should be noted that the percentage removal and overall efficiencies listed above have been obtained under controlled circumstances and may vary greatly depending upon the actual conditions encountered in various sewer systems. These conditions may make the use of swirl concentrators highly ineffective and uneconomical. Among these conditions are the following: 1) in areas where the interceptors surcharge during storms, the free outlet necessary for the concentrated low volume wastewater will not be available, thereby forcing almost all of the flows, including the low volume concentrated wastewater, through the outfall into the river; 2) in flat combined-sewered areas where flooding presently occurs in streets and basements, the problem will be aggravated by the introduction of any device on the combined-sewers, such as swirl concentrators, which will increase the head loss and, therefore, the hydraulic gradient upstream; 3) depending upon the actual volume of concentrated flow introduced by swirl concentrators, the capacity of the existing treatment plant may be exceeded, necessitating bypassing some of the flow past the plant directly to the river; 4) on very large sewers in congested downtown areas, the land required to build a large diameter swirl concentrator may not be available; and 5) swirl concentrators act to remove only certain elements and percentages of the pollution found in C.S.O. Still other alternatives have to be employed in conjunction with them to eliminate the bulk of the problem.

Additional Minor Corrections and Suggested Changes in Wording of Text

(Note that page numbers refer to numbering system which began with the first page of the Executive Report being numbered page 1.)

1. Page 13, under "Overflow Pollution Abatement Projects," 4th paragraph, lines 1 and 11, "Alternative 4" should be "Alternative 3."
2. Page 16, under Mandate, 1st paragraph, 1st line, "Section 516(c)" is referred to, but under Scope, 1st paragraph, 2nd line, the section is referred to as "Section 615 (c)."
3. Page 18, under "The 1978 Needs Survey," 3rd paragraph, 9th line, it is suggested for clarity that the term "an order of magnitude" be changed to "ten times."
4. Page 57, under "Results, Nationwide", 2nd paragraph, 1st line, "Table 6-8" should be "Table 6-7".
5. Page 119, under "Chicago, Illinois, Urban Characteristics":
    a. 1st paragraph, 2nd line, "878" square miles should be "867" square miles.
    b. 1st paragraph, 5th line, "50%" open space should be "15%" open space.
    c. 1st paragraph, 14th line, "16" (Lake Michigan floods) should be "19".
    d. 2nd paragraph, line 3, "3.47 inches" does not conform with what Figure B-8 (p. 120) of that section shows.
6. Page 149, under "Sewer Separation Advantages," item 1, line 1. It is suggested the term "municipal wastewater" be changed to "municipal sanitary sewage."

7. Page 158, under "Screens, Advantages" in line 1 or 2, it is suggested that the words, "(except for microstrainers)" be added.

8. Pages 48 and 49, Tables 6-1 and 6-2, information on Chicago, Chicago Metro, and New York seem to be inconsistent between the two tables. Data for Chicago in Table 6-1 is correct.

9. Page 4, under "Executive Summary, Estimated Time Required...," remove sentence "Because water pollution...viewed a continuous," because it is misleading since it is based on incorrect economic life for equipment and tunnel and gets construction costs mixed up with maintenance costs.

10. Page 7, under "Executive Summary, Pollutant Discharge," change point (1) under annual average pollutant sources in urbanized areas to read: "Secondary WWTP effluent and combined sewer overflows are the major sources of BOD_5." This is definitely true in the very densely developed Chicago area and certainly, we believe, in other densely developed areas.

11. Page 7, under "Executive Summary, Pollutant Discharge...", add the following point (5) to the pollutant sources in urbanized areas: "Combined sewer overflow is the only source of visible, floatable and malodorous untreated sewage in the receiving waterways in those areas with treatment facilities."

12. Page 75, under Appendix C, after Table 7-1, delete the second sentence beginning: "Sewer flushing appears to be the most promising source control..." This sentence is in error and contradicts other statements in the report.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 2 1979

OFFICE OF WATER AND
HAZARDOUS MATERIALS

Mr. Hugh H. McMillan
General Superintendent
Metropolitan Sanitary District
of Greater Chicago
100 East Erie Street
Chicago, IL 60611

Dear Mr. McMillan:

Thank you for your review dated December 21, 1978, of our draft report presenting preliminary estimates of construction costs for the control of combined sewer overflow and urban stormwater runoff (Categories V and VI).

We agree that the recreation receiving water quality objective is the only receiving water quality objective considered which will reflect the fishable/swimable goals of the Federal Water Pollution Control Act. Therefore, the construction cost estimates developed for the recreation objective are the estimates which are reported to Congress as the national needs for Category V. The other receiving water objectives were considered in order to obtain a relationship between receiving water beneficial use and total cost to the public. Such information may be useful for future policy making.

The aesthetics level presented in the final report is based on an optimum combination of sewer flushing and street sweeping and not on the swirl concentrators/screens combination developed in the draft report. We estimate approximately 40 percent of the watershed pollutants (solids and BOD) can be removed by these technologies and an overall removal of this magnitude would have positive aesthetic as well as benthic effects.

Concerning the fish and wildlife protection level, it is possible that direct consideration of ammonia toxicity may have some effect on the cost estimates to meet this objective. However, it is probable that, by meeting the ultimate oxygen demand requirements (which include ammonia oxidation), ammonia toxicity problems will be greatly reduced.

The methodology used to develop the needs estimates for Categories V and VI involves consideration of many technologies. These technologies vary in cost and effectiveness and cannot be readily compared against uniform criteria except for economic criteria, which is the main thrust of the analysis.

Control alternatives considered for combined sewer systems include street sweeping, sewer flushing, and storage/treatment systems. Each of these alternatives were considered directly in the estimation of needs required to meet the fish and wildlife receiving water quality criteria. In cases where the overall pollutant removal is low, the optimum mix will include maximum utilization of sewer flushing and street sweeping and minimum utilization of storage/treatment systems. In the case of Chicago, where the required pollutant removals are high, the optimum mix will include utilization of street sweeping and sewer flushing and maximum utilization of storage/treatment systems.

We agree that, for extremely high pollutant removals, storage/treatment is the only technically feasible alternative. For this reason, recreation level needs, which are the needs reported to Congress, are based on providing storage/treatment systems which will limit the total number of untreated overflow events to two per year. Street sweeping and sewer flushing are not considered under the recreation receiving water objective. For the combined sewer area of Chicago, needs are based on providing 6.0 billion gallons of offline storage and a wet weather treatment capacity of 1.2 billion gallons per day.

We agree that there is no substitute for observed data when assessing a water pollution problem. However, a nationwide inventory of available receiving water quality data revealed only three urban areas in the United States with adequate retrievable continuous dissolved oxygen data to calibrate a continuous simulation model.

The "Continuous Stormwater Pollution Simulation System" (CSPSS) was developed for and used in the 1978 Needs Survey to derive relationships between urban characteristics and receiving water quality in the 15 receiving water site studies. Pollutant removal requirements for each of the 320 urbanized areas were then estimated using these relationships, rather than application of the continuous receiving water model. Therefore, the CSPSS was not applied to Chicago.

Although CSPSS was not applied to Chicago and its receiving water, we would like to address the deficiencies which you perceive to be inherent in the receiving water response component.

1. Nitrogenous Oxygen Demand. The nitrogenous oxygen demand is included in the model as one of four dissolved oxygen sinks considered. This does not imply, however, that simulation of nitrogeneous oxygen demand is required. If nitrification within the receiving reach of interest is negligible, then the TKN loading rates may be set to negligible values and this load will not be included in the computations.

2. Sediment Oxygen Demand. There are no default values for sediment oxygen demand utilized in the model. The values for sediment oxygen demand reported in Table 9-3 of the users manual are typical literature values to be used as a guide in the absence of measured values, which are rare. The source of this information is fully documented.

3. Upstream Water Quality. Again, there are no default values for upstream water quality parameters in the model. A background suspended solids concentration of 7 mg/l, shows in the urbanized area data base for Chicago, is used in the final needs computation by the Needs Estimation Program which is listed in Appendix D.

4. Dissolved Oxygen Concentration. CSPSS simulates receiving water dissolved oxygen concentrations on a continous basis for as many years as the user desires. Therefore, dry-period dissolved oxygen levels, as well as wet-weather dissolved oxygen levels, are simulated as they occur in the prototype. No assumptions need be made as to "critical" conditions, since all conditions are considered. The difficulties encountered in the definition of critical loadings and/or design conditions is, in fact, the problem which precipitated the development of a continuous simulation approach which considers all pollutant sources and all loading conditions.

5. Model Utilization, Calibration, and Verification. The ultimate uses of the simulation model for this project were to study 15 urban areas and to develop transferable principles and relationships which are then used in the national needs estimate. There is no doubt that a certain degree of uncertainty is introduced by this process and that this uncertainty will decrease as more observed data become available. The final report will contain an additional chapter on sensitivity not presented in the draft report. This chapter will attempt to quantify the uncertainties associated with the present needs estimates.

Nevertheless, we believe that the major variables which influence combined sewer pollution control needs are included in this survey.

The Sanitary District of Greater Chicago has invested much time and effort in identifying a cost-effective solution to the serious combined sewer overflow and flooding problems in Chicago. As you stated in your letter, the estimated cost for the Tunnel and Reservoir Plan (TARP) is $2.1 billion. Since the TARP is a multipurpose project, only the cost for water pollution control can be considered in Category V as grant-eligible needs. The present EPA estimate of grant eligible water pollution control funding for TARP is approximately $1.70 billion. The 1978 Needs Survey estimate of grant eligible funding for Chicago is $1.52 billion and $3.00 billion for the State of Illinois. Of these total needs, approximately $871 million were met before January 1, 1978.

It is unfortunate that limited time and resources are available to perform the nationwide survey of water pollution control costs. However, we feel that the analysis presented in the 1978 Survey is a significant improvement over past surveys and presents a state-of-the-art analysis of combined sewer overflow and urban stormwater pollution problems.

The final report, including all comments and corrections received by the States, will be forwarded to you in March, 1979.

I hope that my letter has answered your questions. If I can be of further assistance, please contact me.

Sincerely yours,

J. A. Chamblee

James A. Chamblee, Chief
Priorities & Needs Assessment Branch (WH-595)

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